OUR·TEETH
HOW·BUILT·UP HOW·DESTROYED HOW·PRESERVED

PEDLEY·AND HARRISON

Lewis M. [illegible]

OUR TEETH

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HOW DESTROYED
HOW PRESERVED

DESCRIBED AND ILLUSTRATED BY

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PREFACE

This book is written and illustrated for all who take an interest in their own health and in the welfare of the community.

So prevalent is disease of teeth in children that the public have come to regard it as a normal condition for every child to have one or more carious teeth. This is an erroneous impression. A child can no more be regarded as normal who has carious teeth than if he had pulmonary consumption.

This book seeks to explain, what is unknown to the majority of educated men and women, viz.: the causes of dental diseases, the means of preventing them, their effects, and the need for their rational treatment.

If it be necessary to justify the publication of such a work, the justification is comprised in the following facts:—

1. Of all diseases among civilized communities, dental diseases are the most prevalent.
2. More than three thousand men were invalided home during the late Boer War, on account of defective teeth.
3. More than eight hundred out of every thousand children in the United Kingdom are suffering in one form or another from diseased or defective teeth.

Much has been done for the control and prevention of dental diseases during the past decade. The teeth of the soldier and the sailor are no longer entirely neglected; and the teeth of the children of the poor are receiving in some small measure the regular attention which they so much need.

In order to cope adequately and effectually with preventable diseases it will be necessary to inaugurate a public medical service in connection with the homes and the schools throughout the country. In this should be included an efficient dental service. Systematic examination of the school children must be followed by systematic treatment. An extension of responsibility in this matter, of those who control the education of the young, is also necessary.

With examination and treatment should come teaching. This teaching of the scholars must include a knowledge of their own bodies; how they are nourished and how they become the victims of disease if the precepts taught are not carried into practice. The further we trace the causation of diseases, the clearer the evidence becomes that "the people perish for lack of knowledge", that "Ignorance is God's curse . . . knowledge the wing by which we fly to heaven".

The authors gratefully acknowledge the help they have received from Professor J. S. Macdonald of Sheffield University in the microscopic photography, also from Dr. A. Newsholme, Medical Officer to the Local Government Board, and Professor C. S. Sherrington, F.R.S., of Liverpool University, who have kindly read and criticized the book.

To these personal friends the authors are deeply indebted and record with pleasure their hearty thanks.

R. D. P.
F H.

October, 1908.

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INTRODUCTION

Mastication or chewing is one of the most important functions of human life. It is the first act in the preparation of food for a series of chemical changes, called digestion, which enable nourishment to be taken into the tissues of the body, and life to be thereby sustained.

Mastication is controlled by the will of the individual, its impulses being conveyed by nerves from the brain to the muscles attached to the jaws. These muscles, by alternate contraction, bring the teeth of the lower jaw against those of the upper jaw and separate them again, and the material between the teeth is ground with great pressure, as corn is ground between millstones, one of which is fixed.

Simultaneously with this grinding, and as a result of nervous impulse, saliva is poured out of reservoirs—or glands—through minute tubes—or ducts—into the mouth. Two of these glands are situated on each side of the face, and two beneath the lower jaw, under the tongue.

As the food is ground it is mixed into a pulp by the muscles of the tongue, cheeks, and lips. The starch in the food is turned into sugar, and while this chemical change is taking place the mass of masticated food is swallowed and passed into the stomach, where it is further acted upon by other digestive juices. Thence it passes to the intestines.

Rarely is any defect found in the muscles of the jaws; under certain conditions the saliva is imperfect; but the teeth are very often defective or diseased, and the process of mastication is thus interfered with. Under healthy conditions mastication is a pleasure, but it is painful under faulty

conditions, and is then, consciously or unconsciously, avoided as much as possible. The immediate effect is that the food is not digested, and the health suffers as a result. There are other harmful consequences which will be dealt with later on, but it is sufficient here to point out that ill health is the most important.

In animals other than man, the teeth rarely suffer, but when they are defective, and mastication is hindered, ill health results, as in man. If the animal is young, and these defects are neglected, starvation and death follow; if old, the animal becomes useless.

The simplest cure for a diseased tooth is to remove it, and certainly this method of treatment is effectual, because it stops all pain. From time immemorial this has been the universal remedy, though not the wisest, as a moment's reflection will prove. For when one tooth is removed, the opposing tooth loses most of its grinding capacity and usefulness.

First impulses for momentary relief are by no means always the best to adopt, if effectual cure is aimed at. An illustration from everyday life may be found in the man who stands at a wayside crossing, an emblem of poverty, in rags. Casual relief by gifts of food and clothes does not redeem the man. He will return again and again to the old state. The question to consider is, how did he get into such a plight? If he had, as a child, been removed from the environment and influences which led to his downfall, his present state of poverty, which has become chronic, might have been prevented.[1] Similarly, those who study diseases have first to understand how the body is constructed, to know something of the laws by which physiological actions are governed, and to trace the symptoms back to their beginnings, in order that true remedies may be adopted for their cure.

The proper treatment of dental diseases is no exception to this rule. Symptoms must be traced back to causes, and these causes, so far as practicable, must be removed.

[1] *Vide* Dr. Barnardo's Homes.

In the following pages we shall endeavour to explain, in the simplest language and by the clearest illustrations, the structure of the teeth from a very early age; how they are built up, and why they are gradually destroyed. We shall seek to trace the causes of dental disease, and to make evident the means by which the teeth may be preserved. In addition, the beneficial effects of such treatment upon the individual and upon the community will be considered. In other words, we shall hope to prove the necessity of having a healthy mouth in order to keep a healthy body; also to prove that not only is prevention better than cure, but that prevention is the best cure.

CHAPTER I

THE STRUCTURE OF THE TEETH

Cellular Structure of a Tooth, and its contents—The Circulating Blood —Nerve Fibres—Teeth embedded in Bone—Structure of Bone—Types of Bone Tissue—Structure and Functions of Nerves—All Living Bodies formed of Cells—General Structure of Human Body.

In order to ascertain by what means our teeth may be preserved, we must first ask: What are teeth? The answer seems sufficiently simple. A tooth—for, except in shape, they are all much alike—is a hard mass implanted in the jaw for the purpose of mastication. The portion projecting from the gum is called the crown, that buried in the jaw the root; and in order that the continuity with the rest of the body may be maintained, its centre contains a network of nerves and blood vessels connected with the larger nerves and larger blood vessels.

The truth of these facts is obvious to anyone who will consider the matter, for we all have, or have had, teeth. By them our food is masticated, and when unfortunately we lose one we see that it has one or more roots. The pain of toothache affords sufficient evidence of the nervous connections of the tooth, and the blood lost after the removal of the offending member shows the continuity with the blood vessels and the blood freely circulating through the jaws.

Teeth are the hardest structures of the human body. To what is this hardness due? Most householders, and especially those who live in chalky districts, know that a hard substance collects in the water pipes and on the inner surfaces of kettles. This, which is generally spoken of as *fur*, is composed of lime

salts. If a small piece be placed in hydrochloric acid and water it gradually disappears; it has been dissolved. Teeth contain a large amount of lime salts, and if a similar experiment be made by dropping a tooth into acid diluted with water, it will be found that the lime will dissolve; the enamel —the hardest part of the tooth,—which covers the crown, will disappear, leaving behind a milky film; and the tooth, although still retaining its shape, will be soft enough to be cut with a knife, the loss of its lime having converted it into a piece of gelatine, so that when a section is stained and placed under a microscope it is seen to consist almost entirely of fine fibres.

In the embryonic condition, when the tooth is very young and quite soft, these fibres are minute cells, which, when fully formed, become permeated with lime salts. Cells, in fact, form the whole tooth, including its nerves, the blood and the capillary tubes through which the blood circulates, and the bone in which it is implanted. To these latter structures we shall ask the reader's attention before attempting to describe the elaboration of cells into a complete tooth.

Fig. 1 illustrates the microscopic appearance of the blood magnified 550 times. Floating in a clear fluid is a mass of living cells, the red and white corpuscles. By far the greater number of these are the red corpuscles, which are capable of changing their shape when compressed. They contain a complex fluid which gives to the blood its colour, and enables them to absorb oxygen from the air when circulating through the lungs. Hence the red corpuscles are the oxygen carriers. The two larger cells, which are somewhat isolated, are the white corpuscles. These are protoplasmic cells; they are irregular in size and contain distinct granules or nuclei. They move independently of the blood stream, and often change their shape and pass through the walls of the capillary tubes into the neighbouring tissues, and from the remarkable capacity which they show in enclosing and taking into themselves bacteria (p. 80) they are described as the phagocytes—the wandering protectors or soldiers of the body. The clear fluid or blood plasma in which these corpuscles float contains many

substances dissolved; among them are *proteid* food material (p. 43) and salts in solution, by which the tissues are nourished, built up, and their waste repaired. Part of this fluid in course of circulation exudes through the walls of the

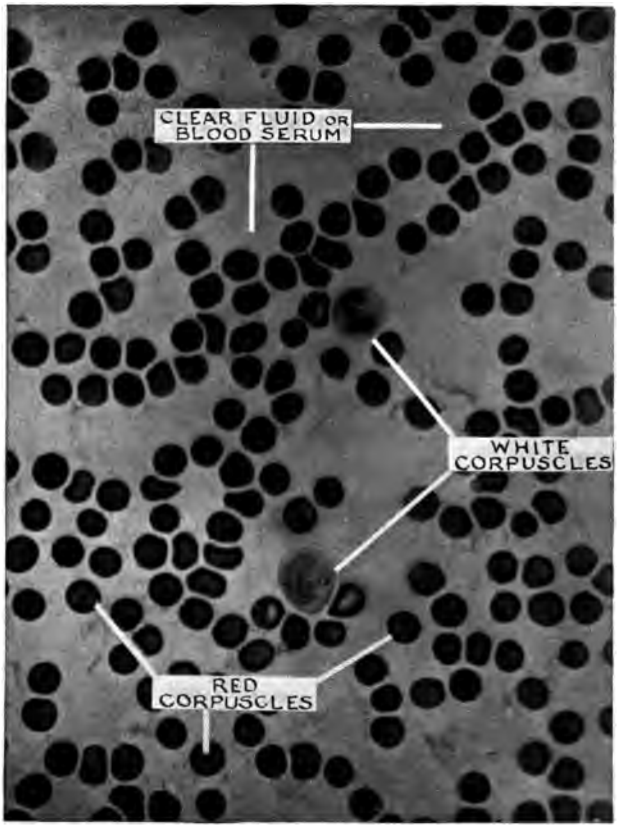


Fig. 1.—Human Blood

capillaries to become the lymph, which bathes all tissues in the body. Through the medium of the lymph oxygen is supplied to the cells and waste products are removed.

Bones are hard, because their cells, like those of the teeth, are permeated with lime salts.

Fig. 2 is an illustration of bone magnified 230 times. The gelatine has been removed by boiling and only the framework remains. The central cavity contained the blood vessels and nerves. Layer upon layer of cells surround it, and extremely fine channels, like wavy lines, may be seen traversing the whole structure. This may be compared to a section across the root of a tooth (fig. 23), and

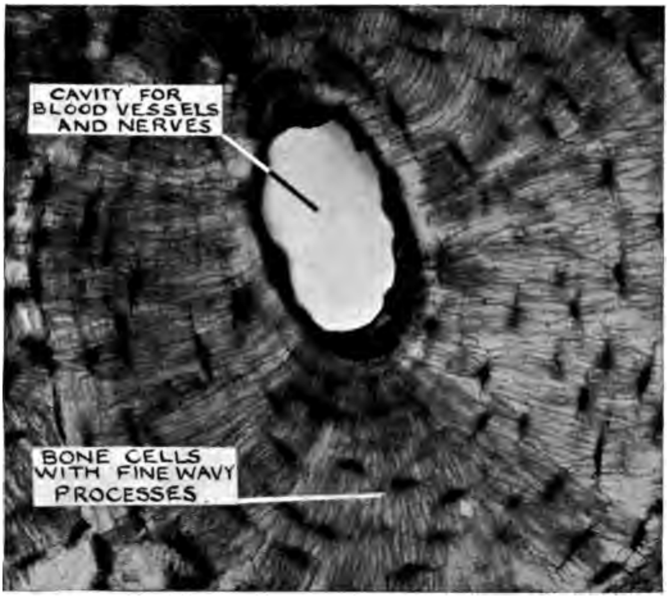


Fig. 2.—Transverse Section of Bone. × 230

it shows how nourishment is conveyed from the centre to the circumference. On referring to fig. 22 it will be seen that the tooth pulp is situated immediately beneath the dentine and enamel which form the crown. This pulp is composed of a delicate network of blood vessels and nerves. Surrounding them is a layer of cells, and fine prolongations from these run throughout the dentine or ivory of the tooth. Sensation—pain—is transmitted from these prolongations to the filaments of nerve in the root of the tooth; these fila-

ments join the larger nerves in the jaw, and eventually carry the sensory impressions to the brain. To take a familiar illustration, trace the path of the electric current from the filament of a lamp on our table; we find that it passes to the copper wire, joining others on their way to the basement, and

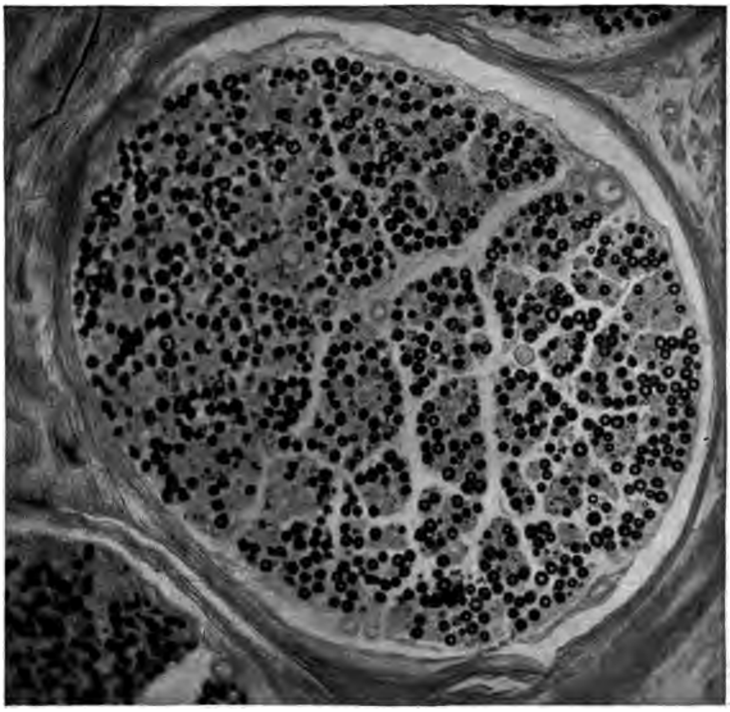


Fig. 3.—Transverse Section through Nerve Trunk. × 225

proceeding from thence through a cable to the generating station. Fig. 3 is a section through a nerve trunk, or cable, magnified 225 times. It is made up of many smaller cables, all bound together by fibrous tissue cells, with here and there a blood vessel. Fig. 4, a section through one of these smaller trunks or cables, shows the individual nerve fibres magnified 675 times. Many are enclosed in a sheath, others are not.

The central core is the axis cylinder, and may be compared to the copper wire of the electric system, along which the current flows, and which may be covered by a sheath of silk or gutta percha or may be quite bare. Each axis cylinder is the prolongation or branch of a nerve cell. Nerve cells vary in size and shape. Those illustrated in fig. 5 have several branches, and are found in the spinal cord. Each cell in itself may be regarded as having independent existence, and as being a complete generating station. One branch of the

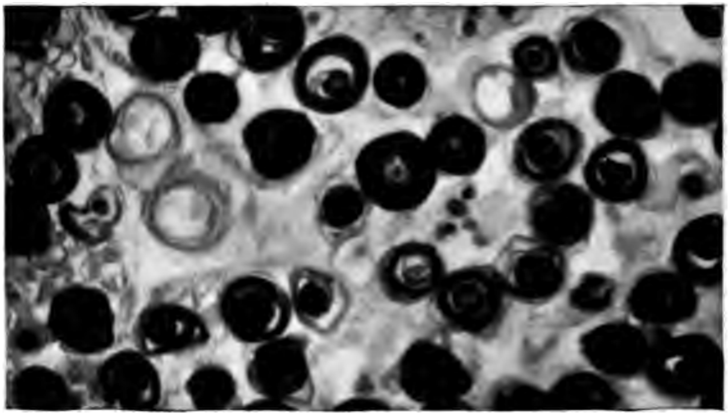


Fig. 4.—Detail of above highly magnified. x 675

cell grows on and on until it terminates in bone, tooth, skin, or muscle, its particular end being fashioned according to its environment. Another branch of the cell may be traced in the opposite direction until it ends in the brain. Long as these branches are, it is only by their continuity with others that it is possible for nerve impulses to be carried. Through these cells and their delicate fibrils each tooth is linked with its fellow and with the whole body, as wires link up room with room and house with house, and finally join the great generating station.

It is important to understand the function of cells in organisms. All living structures, whether of animals or

plants, are built up by cells varying in size, shape, and function according to the tissue built. These cells are composed of a living material called protoplasm, "exhibiting a reticular or spongelike structure with a clear or finely granular substance in its meshes".[1] Within this are small bodies called nuclei, and within these again are smaller bodies (see fig. 9). Often there is a well-defined cell wall.

Fig. 5.—Longitudinal Section of Spinal Cord. × 125

By a series of remarkable changes—too technical to describe, and indeed not yet fully understood—the nucleus divides into two or more; this process is followed by a division of the whole structure, and a multiplication of the cell takes place. From these protoplasmic cells are elaborated what are described for convenience as the systems of the human body. These comprise (1) the bony framework, with lime salts deposited in its cells, giving stability and strength; (2) the muscles, by which most of our actions are

[1] Professor Schafer, F.R.S.: *Textbook of Physiology*, Vol. II, p. 594.

performed, covering the bones and attached to them; (3) the vessels through which the blood circulates, and the blood itself, conveying nourishment to all parts; (4) the digestive organs, including the secretory glands, by which food is broken up, digested, and taken into the circulation; and (5) the brain and nervous system, the controllers of our whole being. In the growing body all these systems are being formed simultaneously, without undue haste, silently, and unseen to the human eye. We consist of cells from the crown of the head to the soles of the feet. With a perfect division of labour these protoplasmic cells build out of themselves and of themselves the woof and web of the body substance. They manufacture all they require from raw material, supply the necessary force for all vital actions, supply their own nerve impulse, store up food for supporting and renewing strength, and remove their own waste products. "They breathe, they assimilate, they dispense their own stores of energy, and repair their own substantial waste; each, in short, is a living unit, with its nutrition more or less centred in itself."[1]

[1] Professor Sherrington, F.R.S.: *Integrative Action of the Nervous System*, p. 2.

CHAPTER II

THE BUILDING UP OF THE TEETH

Early Stages of Building—Sections as seen Microscopically—Various Stages of Growth—The Enamel or Roof Builders—The Ivory or Dentine Workers—The Working Cells Separately Studied—Their Supplies and Nourishment.

Surrounded as we are by plants and animals in varying stages of evolution, familiarity often ceases to create more than a passing feeling of wonder. But when the study of living structures is extended to fields unseen by the naked eye, into that region of minute cell life only discernible through the lens of a microscope, wonder is intensified and the spirit of enquiry is aroused. It is this desire for knowledge which has engaged a numerous band of workers in microscopy; improving the lenses, so that higher magnification can be attained; embedding the tissues in various preparatives which shall preserve their structures; and staining them in different chemical fluids, so that the various cells may be delineated. These workers have also called to their aid the photographic plate to record faithfully what is seen. Taking advantage of all these labours, the student may follow the orderly sequence of nature, and obtain some knowledge of the evolution of cell life into the complete structure. And it is not uninteresting, and will be useful to our present purpose, to follow it in the structure of the teeth.

Fig. 6 is a section through an embryo jaw. On the left side, above, a narrow, uneven line marks the surface of the gum. Above this is a mass of epithelial cells, which forms

a ridge along the rudimentary jaw. A vertical line indicates the spot where a portion of this epithelial layer has grown into the jaw. Below, it has expanded into a bell-like structure—the enamel organ. Ten of these enamel organs are found in each jaw. Each enamel organ is met by a small mound from the deeper tissue, growing upwards and shaping the cap of epithelial cells; this is the dental germ. By the side of this embryo temporary tooth is a vertical line of cells which has grown down in the form of a wavy tube; this will eventually become the enamel organ of a permanent tooth. A section through an embryo jaw at a later stage, as in fig. 7, shows that remarkable changes have taken place. The vertical band by which the enamel organ was attached to the gum has disappeared. The rudimentary tooth is isolated. Enclosed in a membrane—the dental sac—the enamel organ and the dental germ are more highly organized. Fig. 8 shows a portion of the same structure greatly magnified. The shape of the tooth is determined. The three layers of cells which form the cap of enamel are undergoing rapid change. Surrounding the apex of the dental germ is a clear space. Immediately below this is a layer of cells, cylindrical in form, with well-marked nuclei. These facts may be rendered still clearer if it can be realized that the pictures are actual stages in the life-history of what was at one time living tissue.

It is recorded of the ancient city of Pompeii—buried so long beneath the ashes of Vesuvius—that when death came the soldier was found at the post of duty, the workmen were constructing their buildings, and the citizens attending to their daily occupations.

The sections in figs. 6 to 9 may be regarded as records of the past, as small portions of a buried city. The finished buildings will be seen later. We have in the previous description endeavoured to trace the ground plan, to see how the foundations are laid, and to form some conception of how the walls are built. Now we have reached a point at which we can see the workmen engaged in building up the tooth. The

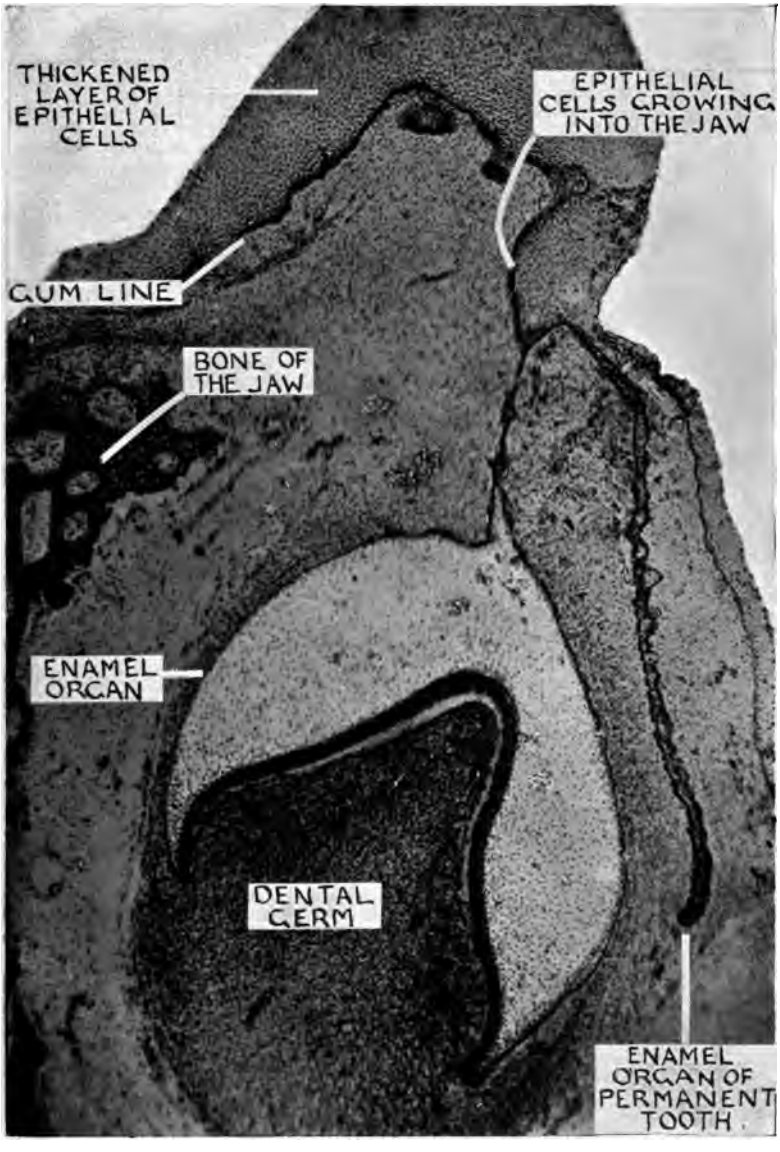


Fig. 6.—Early developing Teeth. × 75

The skin of the mouth folds in to form the enamel of the temporary tooth. The permanent tooth is an offshoot from the temporary tooth.

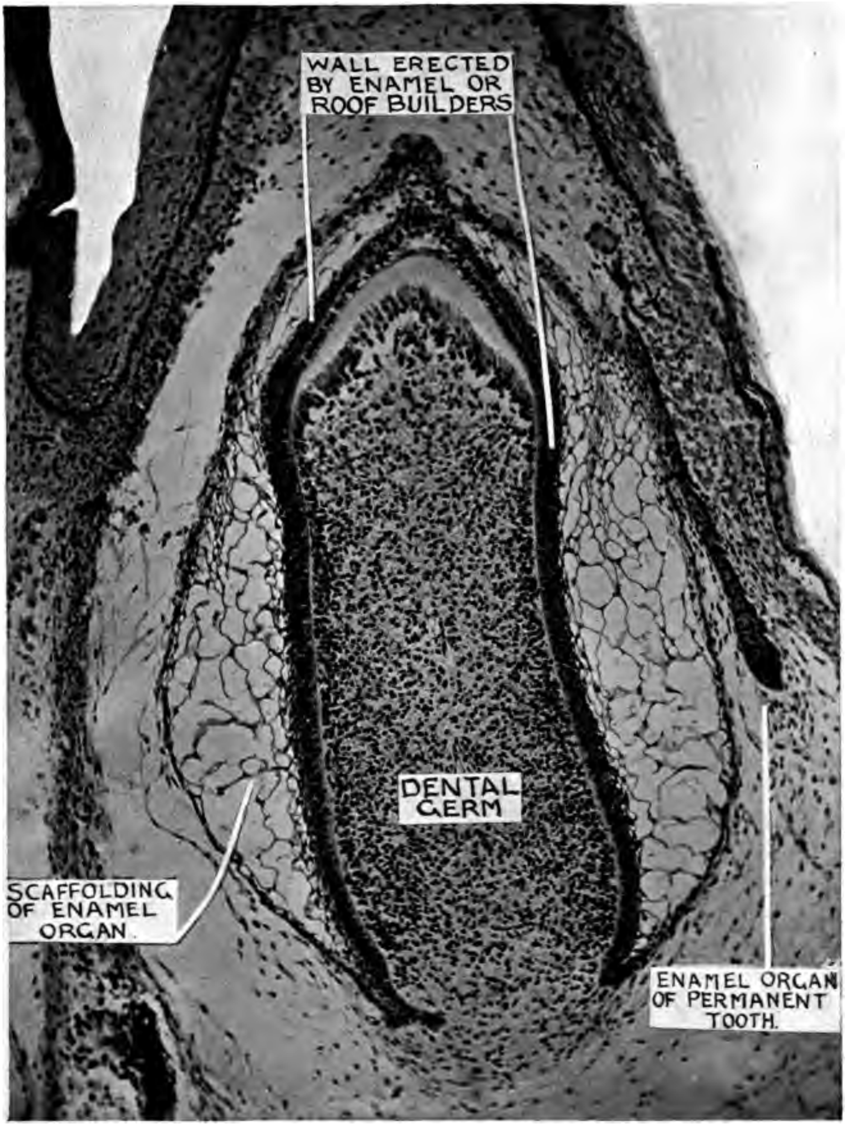


Fig. 7.—Developing Tooth. × 125
By Graham Simpson, F.R.C.S. and L.D.S., Eng.

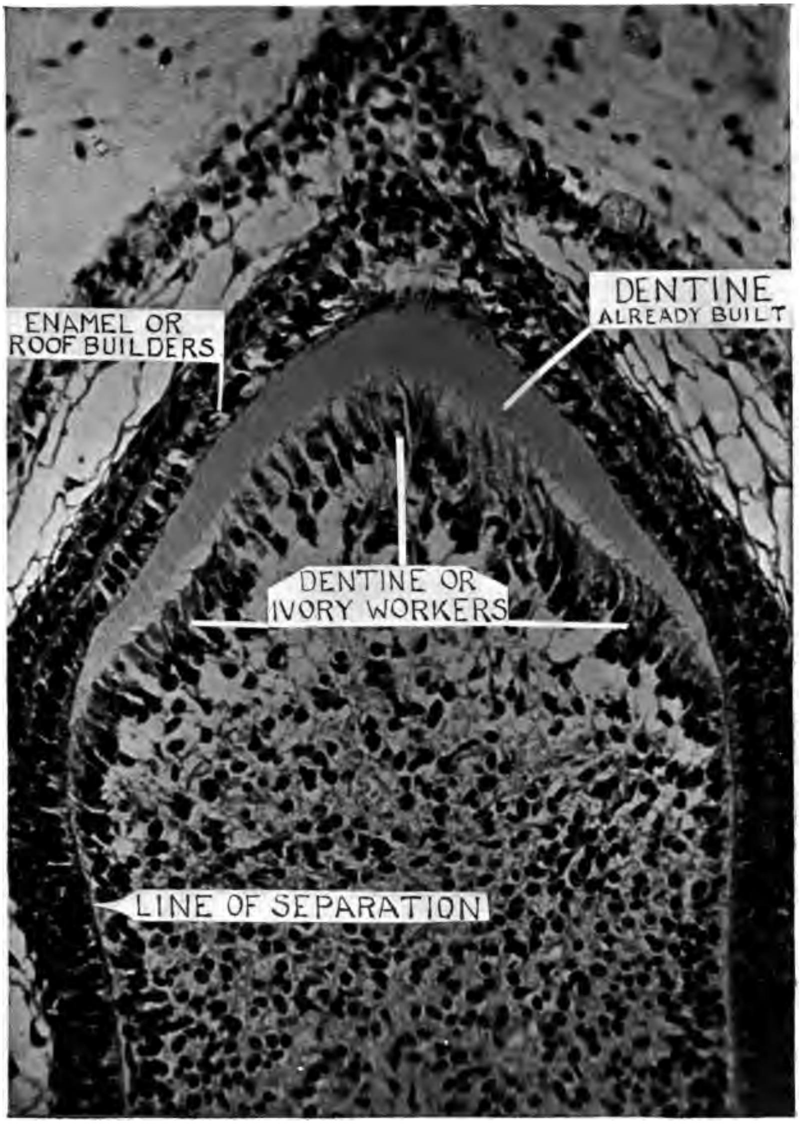


Fig. 8.—Developing Tooth. × 375

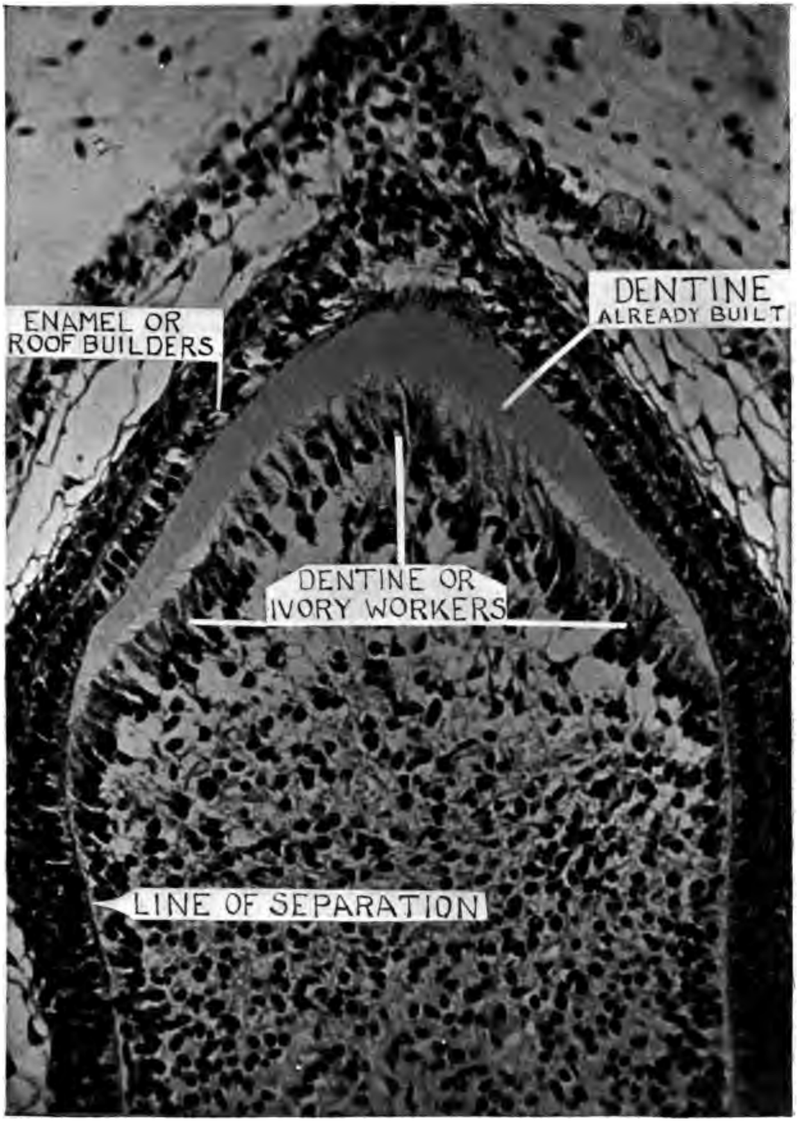


Fig. 8.—Developing Tooth. × 375

illustrations show the builders at the post of duty. It should always be borne in mind, as mentioned in the previous chapter, that the citizens of this vast human city build out of themselves and of themselves most complicated structures; in brief, the workmen are the materials and also the tools.

The sections shown in figs. 6–9, being taken from embryo animals during the stage at which the temporary teeth were growing, may thus be compared to the structures and workers in Pompeii.

In fig. 6 an army of workers has entered, as it were from above, in two places. In one place is seen the roof of the tooth; by its side is a smaller portion which will ultimately be the roof of another tooth. Coming to meet this army from below is another army, in the shape of a small pyramid—the dental germ. These workers subsequently fashion the whole of the inside of the building—repairing, shaping, furnishing, as they come and go.

In fig. 7 are similar structures, but in a later stage. Every trace of the way in from above has been removed. The roof workers have extended their operations by building a scaffolding from the top of the building right down to the base on each side, shaped like two horns. Inside this scaffolding they have built a continuous wall, which may be traced from the points of the horns below as a thick line meeting above at the apex of the roof. There is a breach in the scaffolding above on the right, where a continuous band of workers are engaged on a small clublike structure. This also is a further stage in the construction of another roof, which in fig. 6 was but a narrow wavy line.

In fig. 8, highly magnified, the individual working cells can be seen. A line, as if drawn with a pen, separates the roof from the inside workers. The clear space below that line is the part of the dentine which is first formed, and the long cells heaped up below and close to it are the workers producing this dentine. Thus an arch of dentine or ivory has been built. On this arch the enamel or stone

roof will be constructed, and the whole of the scaffolding will then be removed.

If a few of the working cells are separately studied it will

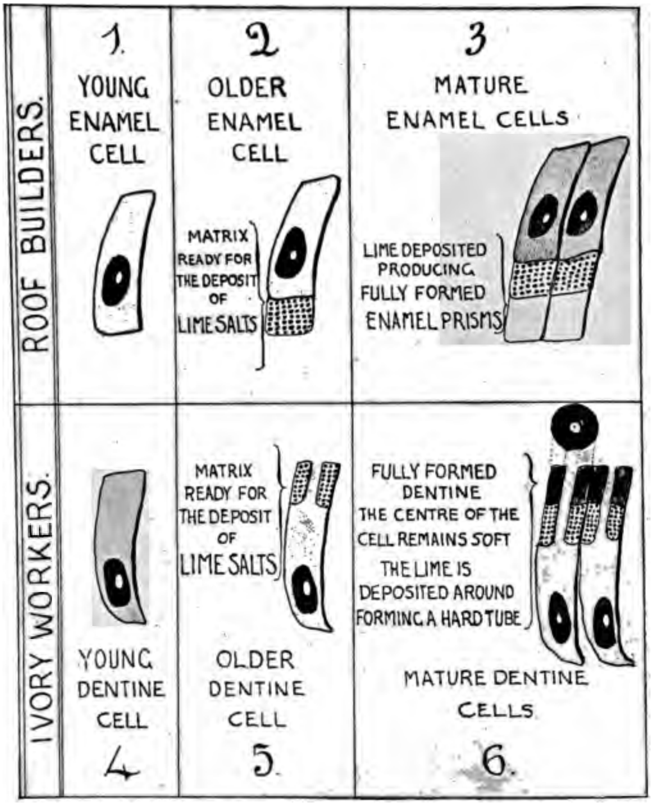


Fig. 9.—How Lime is deposited in growing Enamel and Ivory Cells.

be possible to obtain an insight into their methods of construction. This is seen in fig. 9.

At 1 is a young enamel worker. At 2 is an older enamel worker. At its base a fibrous felting or matrix is seen, and lime salts will be deposited there. At 3 are two mature enamel workers. The lime salts are deposited at their base;

the fibrous matrix is ready above, and in a short time these two workers will be complete enamel prisms. Below are the workers in ivory or dentine. At 4 is a young dentine or ivory worker. At 5 the fibrous matrix is ready to receive the deposit of lime salts. A peculiar interest attaches to this formation, in that the sides only are prepared to receive the lime deposit. At 6 the two dentine workers are maturing, and have already received a deposit of lime. Each one is a small tube, and when completed is of considerable length, extending from the ivory roof to the centre of the pulp chamber. It should here be mentioned that when the roof builders have done their work no further supplies of nourishment are needed by them. The ivory builders, on the contrary, require constant supplies, not only while their building operations are being carried out, but during the whole life of the tooth. These supplies are conveyed through the centre of the tubes by a portion of the original cells which remains as a soft fibril in these tubes. This will be more evident when we come to discuss the question of disease as it affects these tubes. *Vide* Chap. VI.

It should be noted that the enamel builders construct from within outwards, while the dentine builders construct from without inwards. In other words, they build in opposite directions.

The cells at the base will ultimately form the root, but not until long after the tooth has passed through the gum and commenced its duty as part of the mechanism of the jaw. These are the principal facts in the building up of a tooth out of soft tissues.

Summarizing our preceding description we find that every human being is composed of cell workers. In numbers uncountable, in arrangement perfect, they work without ceasing or obvious rest. Guided by an almost unerring instinct they grow to their duties. Like the immature soldiers, early trained to obedience, they become specialists ere their task is ended. Like an army in the field of operations, some are told off to construct, others to remove all obstacles.

Their supplies are brought to them through the lymph channels by the blood stream, their waste products are removed through the same medium, and they are carefully protected by the wandering leucocytes or white blood cells.

We know that when the supplies are entirely cut off for a sufficient length of time an army ceases to exist, for death comes; but often the supplies are merely deficient, or they are tainted at their source. Under such conditions the soldier will still fight on and the cell worker will do its duty. If, however, this deficiency of supplies extends to materials required by the builders of bridges, or the constructors of arches, or if there be an abundance of material but it is of inferior quality, then obviously those bridges and arches can never really be strong. When the stress and strain for which they were intended comes upon them, weak spots will be found, and long before their allotted time they will break down and fall. This is true of an army on active service and of its engineering works; it is emphatically true also concerning the development and growth of the human body, and particularly so of the teeth, which are now under consideration. For, unlike soft tissues, when once built no additional supplies can affect teeth for good or ill; they must bear their burden on the strength of their original outfit, or break down under the strain of daily use. The original supplies we refer to are *maternal.* By no other way, through no other means, can the necessary upbuilding be secured. It is therefore absolutely essential that the mother shall receive every care, for the sake of her offspring. Her life should be simple in the best sense of the word; no profusion, no need; she must be nourished wisely, with pure air and wholesome food. Her work must be of the lightest consistent with the cares of maternal life; she should not be induced to seek her joys in the devious by-ways of luxury, nor should she be compelled to seek her necessities in the highways of commerce or manufacture. All that can be done in private life, in public life, nationally, should be done to make a mother a happy, healthy woman. Then the supplies for her offspring will be pure and sufficient.

When those supplies are deficient or impure then it is evident that luxury or need has been operating. Both these may lead to impoverished or contaminated supply to the embryonic tissues, and disease is apt to arise under either circumstance. In the development and growth of the teeth defective structure and disease may thus be the result either of poverty or of luxury.

CHAPTER III

THE NOURISHMENT OF THE TEETH—THE FIRST OR TEMPORARY DENTITION

Consideration of a Living Child—Its Growth—Its Nourishment—The Growth of Teeth and Jaws—Suitable Food—Unsuitable Food—Their Effects upon the Teeth—Baby Teats and Comforters—The First or Temporary Dentition.

Leaving for a time the study of cell life as revealed by the microscope, we now pass on to the consideration of a living child, in whose tiny jaws—incredible though it may seem—lie buried more than half a hundred teeth. To their proper growth and development we propose to devote this chapter; but as it is impossible to consider the beneficial growth of any one part of a plant, whether it be the root, the stem, the leaves, or the flower, without due consideration for the welfare of the entire plant, so we cannot describe any one part of an infant, whether it be the teeth or the eyes, the limbs or the brain, without duly regarding that infant as a whole.

In an infant at birth we see a being who, passing from its embryonic life into the light of day, enjoys a separate existence aided by a mother's nurture and care. He is a being so complete yet incomplete that his senses, hitherto dormant, are only now awakening. His bony framework is still so soft that the brain and nervous system, with their endless possibilities, lie sheathed in plates of cartilage, with here and there a thin layer of fast-developing bone. No longer nourished through his mother's blood, he for the first time breathes the external air and commences that exchange of oxygen from the air for carbonic acid given off by the lungs, which is an

essential condition of warmth and life. His digestive organs are immediately called into action; his mouth receives food, his stomach and intestines digest it. His blood not only aids in bringing supplies, but enables the excretory organs to throw off waste products, and forms a medium of warmth, as well as a channel for nutriment and a means of removal of impurities throughout life.

Concealed in each jaw are ten temporary teeth, whose crowns (roofs) are partly built up into hard tissue or calcified. By the side of each tooth, and in process of formation, is the early structure of its successor, a permanent tooth (*vide* fig. 7); and in addition the germs of six teeth, ultimately known as the permanent molars. The words "temporary" and "permanent" are terms used to indicate that the teeth of the first set are intended to serve the purposes of mastication until they are replaced by the teeth of the second set.

Each temporary tooth is partitioned off from its neighbours by a layer of bone, which later will completely envelop it. Thus the jaws contain, in varying stages of growth, fifty-two teeth, twenty-six in each jaw.

Ten of these have crowns partly calcified—the first set; the germs of sixteen others belong to their successors of the second set.

Upon the development of these teeth and of the jaws in which they are implanted depends much of the comfort and happiness of the child.

Bearing these facts in mind it is necessary to know the chief requirements which will secure the satisfactory development of these teeth, and of the infant's body as a whole. These are wholesome food, warmth, fresh air, perfect cleanliness, abundant sleep, and the free use of its limbs. These elementary facts are known so well that at present only the food need be considered.

During countless ages, in all countries and climates, a healthy woman has been provided with the natural, and therefore proper, food for each babe she bears. Fortunately, then, for those who are not only willing but anxious to follow

the dictates of reason and nature, a nursing mother is thus the living testimony of what is wholesome food during the first six to twelve months of her infant's life. That this should be realized in the national life was the hope of a learned Englishman, who nearly four hundred years ago wrote on the care of children in the model city as follows:—

> "Every mother is nource to her own child, onles either death or sycknes be the let. When that chaunceth, the wives . . . quyckelye provyde a nource. And that is not hard to be done. For they that can do it prefer themselves to no service so gladlye as to that. Because that there thys kind of pitie is much praysed . . . ".[1]

Any departure from this natural feeding should be regarded as a misfortune to the mother and a grave peril to the infant. Failing this natural feeding there can be no doubt that the services of a nursing mother—if by any means available—should be obtained. Utopian as the idea seems, it has been adopted not only among Western but also by Eastern nations with success.

Of artificial foods, cows' milk is the best, when pure. It should be diluted with water according to the infant's requirements. The difficulty of obtaining pure cows' milk often leads a mother to try various patent foods, and a further departure from natural conditions ensues.

> "Patent foods present marked inferiorities to human milk as a means of nourishing children; most of them are deficient in fat, and a considerable number of them contain unaltered starch, which children are unable to digest." [2]

Other kinds of indigestible foods, besides patent foods, are given, and the effect on the infant's nutrition is lamentably marked. Although fresh air may be obtained in abundance,

[1] Sir Thomas More: *Utopia*, Book II (1516).

[2] *Interdepartmental Committee on Physical Deterioration* (evidence of Dr. Hutchison), Vol. III, p. 363.

the digestive organs remain unsatisfied, and they rebel. Sickness and diarrhœa result. Convulsions often follow. The bones remain soft, the skin is unhealthy, and the teeth are unable to develop; their eruption—that is, their emergence above the gum—is delayed, and the various so-called "disorders of dentition" are manifested. So grave are the perils that many thousands of infants die yearly in this country alone for the lack of their natural food, and because artificial foods are substituted.

In support of this fact we give one statement from the evidence of Professor Cunningham, F.R.S. He attributes the "shocking" mortality among infants to want of breast feeding.

> "You think it is largely due to that?" "I am certain of it; they are fed upon skimmed milk, starchy trash, and all sorts of abominations. It is not that the parents are not able to get better food; but it is owing to the absolute ignorance of the parent of the proper kind of food to give."[1]

Premature death is the extreme penalty of the law, and it is no exaggeration to say that in a country where one man suffers that penalty there are ten who are punished by less severe penalties for minor offences. So for every infant who dies in its first year in this country through neglect, nine survive to suffer, as the result, and pass their second birthday. Like weakly plants, a large proportion of these may be said to have survived the storms, or when exposed to the wintry wind to have been swept out of existence.

How then does neglect of proper food for babies affect the teeth? We have already pointed out (Chap. II) that the first set have their foundations laid and their structures built up during embryonic life. By sections, likened to portions of a buried city, the individual cells have been shown and their building operations described. Drawing an analogy between the cell workers and an army in the field, the question of

[1] *Interdepartmental Committee on Physical Deterioration*, Vol. II, p. 96.

supplies has been discussed. Without desiring to carry this analogy too far, we refer to it again because of its importance. Although the beginnings of the second set of teeth are found in the embryonic jaw, and it may be said that their foundations are there laid, the actual building up by the ivory workers and by the roof or enamel builders does not commence until birth, just when the crowns of the first set are completed. It is therefore obvious that imperfections in the first set will be due to supplies received before birth, and it is equally true that—apart from hereditary influence, referred to later—imperfections in the structure of the second set will be due to supplies received after birth, during the first two or three years of life. Whether those supplies are sufficient and pure, or deficient and tainted, every day and every week will tell in the infant life for good or ill.

Let us bear in mind one of the very remarkable facts concerning the human body, which may be rendered more evident by a simple comparison. In order to accommodate the increasing traffic, an important railway station has to be rebuilt. Operations are in full force, excavations are made, and buildings are erected over those formerly built and used. At the same time these latter are gradually pulled down and taken away. All this is being carried out without interfering with the traffic of passengers and goods; the whole organization of the railway is not interrupted, and the staff are at the post of duty. During the evolution of the human body the processes of pulling down and building up are going on at the same time. This is most evident in the framework. Long after the bones of the skull are united the brain enlarges, and the bones of the skull enlarge also, in order to accommodate the growth of the brain. The structural alterations are effected by innumerable bone cell workers excavating the inside of the skull, while others are building externally. This is typical of what is being carried out in every bone of the body until completion, including the jaws, which are thus prepared to accommodate the developing teeth.

There is, however, a most important exception. The

crowns of the teeth when once formed, built up, and calcified are finished once and for all. No internal supplies will affect the finished structure, and that fact may serve to explain what to many is a mystery. Many a weakling, who has weathered the storms of infancy and ignorance, grows into a strong man or woman under suitable conditions of environment and nutrition, but with teeth so frail as to break down and fail when in daily use. Thus we often find a strong and healthy individual with very defective teeth.

From these facts it becomes evident that, unless ordered by a doctor, all artificial foods should be avoided, as not containing the nutriment required for the proper building up of the teeth. It should also be added that there are certain accessories to feeding which are detrimental to both teeth and jaws.

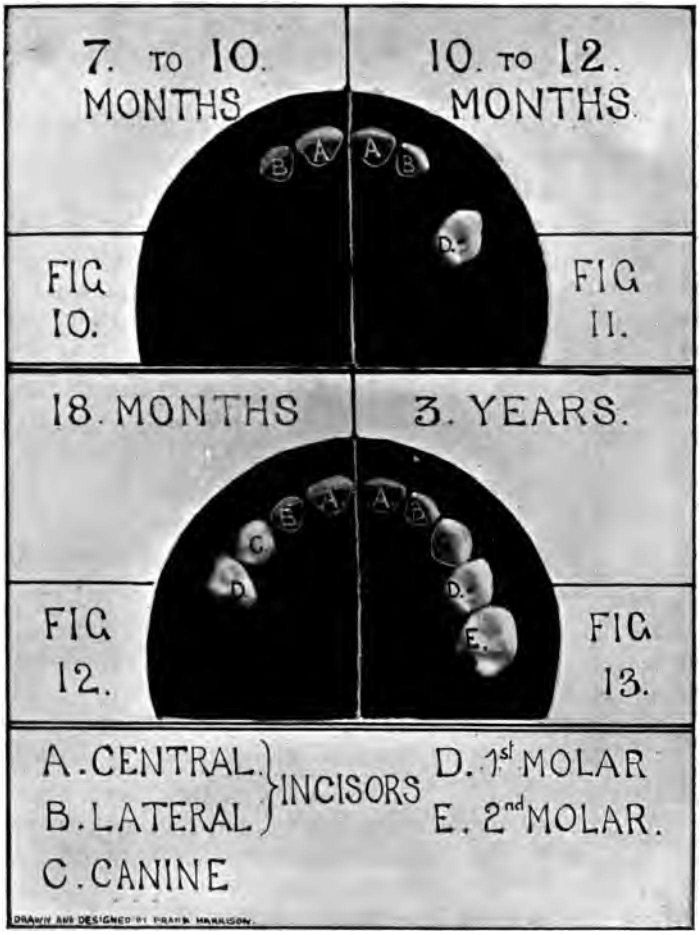
As pointed out by Dr. Tom Pedley, of Rangoon, a physician of many years' experience, rubber teats and baby comforters tend to cause deformities by pushing out the incisive portion of the jaw and inducing enlarged tonsils and adenoids. He states:

> "As a substitute for the common rubber teat I recommend the use of a good-sized soft rubber finger stall; a baby a week old can accommodate the end of one which will fit a man's thumb. Such a teat may be used on the spout of a vessel like a feeding cup, or an ordinary feeding bottle. . . . But a baby three months old can easily be taught to drink from a cup. At this age, then, I would recommend that all teats and bottles be thrown aside, and that we should revert to the oldfashioned metal pap bowl with the long open lip. . . . Of course the baby 'comforter' or 'pacifier' must be abolished and forbidden, for it is injurious."[1]

About the seventh month of infant life a pair of incisors, or cutting teeth, first appear through the gum of the lower jaw

[1] "The Rubber Teat and Deformities of the Jaws", *British Medical Journal*, March 15, 1907.

in front. After an interval of a few weeks a pair of central incisors make their way through the gum of the upper jaw



Figs. 10–13.—To illustrate Eruption of the Temporary Teeth, *i.e.* their emergence above the Gum

(*vide* fig. 10), to be followed almost immediately by another pair by their side, hence called lateral incisors. Then a pair of lateral incisors below. After another interval of a few

weeks, at or about the twelfth month, the first molars appear, generally in the lower jaw first, to be followed by those of the upper a little later (*vide* fig. 11). The appearance of these teeth indicates certain changes which are going on in the jaws. From birth onwards the jaws of a healthy child are growing rapidly and largely by the building up of bone on the outside. The bony plate which separated each tooth now envelops and protects it. The teeth are therefore contained in crypts of bone until their crowns are completed and they are ready to appear. The crowns of the second set are being completed while the first set are ready to emerge. It is not the pressure of the second set, but the operation of some unknown but irresistible forces, that causes the eruption of the first set. There are two stages in the eruption of the temporary teeth: first, the absorption of the crypt; and secondly, the absorption of the gum. The bony crypt is widely open at the top, but not sufficiently so to allow the crown to pass through without removal of some of the osseous (or bony) tissue. As the tooth appears the gum closes round it. Any slight irregularity in position is changed by the action of the lips and cheeks upon the outer surfaces, and the pressure of the tongue upon the inner side.

There is a considerable interval between the appearance of the first molars, or grinding teeth, and of the next pair, the canines, ofttimes from four to six months. So that at eighteen months these teeth may be expected to appear, first in the upper jaw, then in the lower jaw, and on reference to fig. 12 it will be seen that they come between the first molars and the lateral incisors.

Toward the end of the second year the second molars, in pairs, will have passed through the gum (fig. 13), thus completing the eruption of the first set. There are ten teeth in each jaw.

The crowns of these teeth are alone complete, and the roots are only gradually added. Simultaneously with the growth of the roots is the formation of bone, built up around them and ultimately forming their sockets. Although we may

expect to see the crowns of all the first teeth on inspecting the mouth at the end of the second year, the temporary dentition is probably not perfect until the fifth year, or perhaps even later. The whole process is normally a physiological one, and should be accomplished without the manifestation of constitutional disturbance, beyond fretfulness on the part of the child, with slight swelling of the gums and an increased flow of saliva. If any reflex irritation occurs during absorption and the escape of the tooth, it is reduced to a minimum from the fact that the teeth are cut in groups with intervals of rest between, instead of all coming through about the same time. This arrangement is decidedly in favour of the child, but it is also beneficial from the point of view of the development of the jaw. If the back teeth were erupted at the same time as the front, such is the form of the jaw at six months that the back teeth in each jaw alone would come into contact, leaving an "open bite" in front. But the incisors, by being first erupted, separate the jaws in front, and the interval of six months, which follows before the appearance of the first molars, allows the development of the jaw to progress in the normal directions, and by an elongation of the ramus to provide room for the full eruption and regular apposition of the back teeth.

CHAPTER IV

THE GROWTH AND DEVELOPMENT OF THE TEETH

The Presence of Teeth—Nature's Demand for Suitable Food—The Nourishment and Exercise for Growing Teeth and Jaws—Nitrogenous and Non-nitrogenous Foods—Suitable Foods—Unsuitable Foods at this Stage—Their Effects—Digestion of Foods—Early Lessons on Cleanliness of the Teeth—The Mother—The Nurse.

Nature, custom, and experience have all taught us what is the most nutritious food during the first period of life. When an infant has incisor teeth to cut or dig into food, with molar teeth to masticate it, and when his jaws are incessantly at work upon anything the hands can bring to his mouth, we have sufficient evidence that these instinctive movements need satisfying.

References to elaborate tables of diet are more likely to mislead than to guide. They are, for the most part, suitable for the unhealthy.

> "They that be whole need not a physician, but they that are sick."

It is, however, necessary to refer briefly to the chief constituents of food without burdening our pages with particulars which may be found in various manuals of hygiene.

An analysis of human milk proves that it contains nitrogenous and non-nitrogenous substances. Proteid material is the nitrogenous. Fats, carbohydrates—that is, starch and sugar,—salts, and water are the non-nitrogenous. The human body is built up from all these substances. The oxygen of the air may be regarded as a food, as its presence is neces-

sary for the production of the changes in the body-substance which are the source of heat.

Proteid material is the most essential, for without proteids the tissues of the body cannot be built up or repaired. Fats, starches, and sugars are in the main producers of energy, and aid proteids in keeping up the warmth of the body. The fat aids in the assimilation of proteids, and is not only stored up for future use, but acts as a padding to all the tissues. Starch and sugar are easily digested. Salts, organic and inorganic, are essential to life. Without them gastric juice could not be formed, the blood would not be nourished, and bones and teeth would not be built up. It may here be mentioned that there is much more lime in a pint of milk than in a pint of lime water.

Water forms three-fourths of the human body.

The following table will show approximately how much of the above-mentioned constituents is contained in some important foods, taking milk as a criterion:—

IN 100 PARTS

	Proteid.	Fat.	Sugar.	Salts.	Water.
Human milk	3	2.9	5.9	0.16	88.04
Cows' milk	4.9	3.5	4	0.7	86.9
Eggs	13.5	11.6		1	73.5
Meat	27.6	15.45		2.95	54
Fish	18.1	2.9		1	78
Cheese	33.5	24.3		5.4	36.8
			Starch.		
Wheaten flour	11	2	70.3	1.7	15
Oatmeal	12.6	5.6	63	3	15
Peas and beans	22	22	53	2.4	15
Fruits—Organic acids, sugar, salts, water.					
Vegetables—Poor in proteids, rich in salts and water.					

Animal foods contain an abundance of proteid, but are poor in carbohydrates. Vegetable foods contain an abundance of carbohydrates—starch and sugar—in addition to

proteids. A mixed diet and much variety are indispensable for a growing child. If these facts are remembered, all that is requisite is a modicum of parental common sense, guided by the doctor when necessary. If the father takes an intelligent interest in the feeding of his child he can save the mother from being influenced by the traditional ignorance so often displayed by nurses and friends.

When the infant's teeth appear, the child has reached an important stepping-stone on life's journey. He is in a transitional stage as to nourishment. So far he has thrived on milk—an animal food. This must still be given; but as the child is weaned, pure cows' milk is required. To ensure freedom from impurities it need not be boiled, but should be "taken up to the scald", and diluted with barley water. Milk thus treated should for a time form a considerable item in a child's diet morning and evening. When the child is from nine to twelve months old, starchy foods can be digested by the stomach. The teeth then appearing need exercise, and bread—home-made when possible—composed of wheat meal and wheat flour will supply this need; a portion of the top crust, cut in broad slices, should be given to chew, but this crust of bread must not be soaked. Little or no meat should be given before a child is two years of age, but at first bread and gravy from the meat; while bones, without sharp corners, should always be at the child's disposal. Upon these it can exercise its jaws and promote the cutting or eruption of its

ERRATUM

Page 44 (Table), Peas and Beans: col. Fat—*for* 22 *read* 2.2

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Hunger and thirst are sensations prompted by different requirements of the human body. At first they are necessarily inseparable, because an infant's food is liquid. Nature, however, indicates, with the appearance of the teeth, the line of separation in an unmistakable manner. The body requires

far more fluid than solid, therefore at twelve months pure water may be given at any time it is desired, for the simple reason that it is not digested, but passes through the stomach into the intestines, where it is absorbed later on. Many a little one pines for water long before it is able to express its wants, and the giving of milk at irregular times to satisfy thirst not only overloads the stomach, but is a fruitful source of constipation.

At two years of age solid food should be given at meal-times only, in order that the teeth may thoroughly chew. The stomach should also be allowed time to digest one meal before another is given.

Suppose, however, that the parents continue to provide a child with food in a fluid or semi-fluid condition, the child, having nothing to chew, simply swallows its food. The habit of "bolting" is formed—a habit not easily overcome—and the parents, who have never given the matter a thought, wonder why.

The custom of giving children oatmeal with milk, bread soaked or boiled in milk, milk with "patent" cereal foods, is unnatural, in so far as these foods afford no use for the teeth, nutritious as they are in other respects. Oatcake or wholemeal bread made from seconds flour, with the addition of a little butter, to masticate, *followed* by milk to drink, are equally nutritious, and will satisfy the requirements of a child far better.

The modern process of milling, by which the wheat grain is deprived of its outer coat of cellulose or bran, renders the flour white of colour, and of the form of a superfine powder. When examined under the microscope pure wheat flour is found to be entirely free from fibrous particles. It makes good bread, nutritious and easy of digestion, but we believe that it is very destructive to the teeth. The bran in wholemeal bread is most beneficial as a mechanical cleanser of the teeth, when well masticated, whilst in wheat-meal bread the entire absence of fibrous particles causes it to cling to the teeth. Often, unfelt by the tongue and the mucous

lining of the mouth and the lips, it lodges between the teeth without being a source of irritation to be removed, and there this starchy food, by the action of micro-organisms in the mouth, undergoes acid fermentation, and is the chief cause of dental caries or decay (*vide* Chap. VI).

Children are very early led to acquire a taste for the softest food, to avoid meat when it is tough, and bread when it is crusty or stale. On the other hand, the proper use of the muscles of mastication, and the pressure exerted on the teeth and gums by the grinding of food, increase the supply of blood which nourishes both jaws and teeth, and thus favour their growth and development. Further, when food is slowly and deliberately chewed a nervous influence is exerted upon the salivary glands. They are induced to secrete an abundance of healthy saliva, containing sufficient of the ferment ptyalin to perform the necessary chemical change of starch into sugar. Little as we may think it, the character of the saliva has much to do with disease in teeth.

So hazy are general ideas upon digestion, and yet so important is a true knowledge of its nature, that we propose to consider briefly the main facts.

Digestion commences in the mouth with the conversion of starch into sugar. Food passes down the swallowing tube—the œsophagus—into the stomach, which is a muscular sac connected with a muscular tube of considerable length—the intestines—in which digestion is not completed until the waste products are thrown away from the body.

As food enters the stomach an abundant secretion of gastric juice is poured out from glands in its walls. This acts upon proteid material, such as meat, and dissolves it. Powerful muscular contractions churn up the contents of the stomach and bring every particle into contact with the gastric juice. From the stomach the food is passed on to the intestines, where it is acted on by secretions conveyed through minute tubes from the pancreas and the liver—both large glands. The pancreatic secretion completes the work commenced by the saliva, of converting starch into sugar, and the

breaking up of proteids commenced by the gastric juice. The bile dissolves and emulsifies the fats. While these processes are in operation absorption of the dissolved food is taking place through the walls of the small intestine, while water is largely absorbed through the walls of the large and small intestine.

Digestion is therefore the breaking up and dissolving of food throughout the whole of the alimentary canal, and its absorption, the food passing in a fluid condition through the delicate membrane which lines the walls of the intestines. This is by no means a passive process. The muscular coats, although independent of the will (and therefore described as involuntary muscles), are in a state of motion so long as digestion is going on, controlled by nervous impulses. Any such phrases as "easy of digestion", "most nutritious", "pre-digested", &c., concerning soft foods, should be received with a considerable amount of scepticism. It should be remembered that not only do the teeth need exercise, but the muscular coats of the intestines also, and that both suffer for the want of it when soft foods only are used.

The food ultimately passes into the blood, to renew waste tissues, to build up the body, to give energy, heat, and indeed life.

> "'True is it, my incorporate friends,' quoth he,
> 'That I receive the general food at first,
> Which you do live upon; and fit it is,
> Because I am the storehouse and the shop
> Of the whole body: but, if you do remember,
> I send it through the rivers of your blood,
> Even to the court, the heart,—to the seat o' the brain;
> And, through the cranks and offices of man,
> The strongest nerves and small inferior veins
> From me receive that natural competency
> Whereby they live.'"[1]

At twelve months old, or even earlier, the mother's first lesson to her infant in cleanliness of the mouth may be given

[1] *Coriolanus*, i. 1.

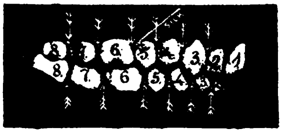
(*vide* fig. 14). Each time she bathes the child she should thoroughly brush her own teeth, then cleanse her mouth with tepid water, taking care that the infant sees these operations

THE CARE OF THE TEETH.
BRUSHING AND SILKING.

THE MEDICAMENT USED WHETHER A DENTIFRICE OR GOOD SOAP AND WARM WATER IS NOT SO IMPORTANT AS THE METHOD OF USING

I.

II.



WHEN CLEANING THE TEETH THE GREATEST CARE IS TO BE BESTOWED UPON THE REMOVAL OF FOOD AND DEBRIS FROM BETWEEN THE TEETH. IT IS BEST TO USE A BRUSH WITH BRISTLES CUT TO CONFORM TO AND REACH THOSE SPACES AS SHOWN IN DIAGRAM. I.

IN USE THE BRUSH SHOULD NOT BE ALLOWED TO PASS TO AND FRO FROM THE FRONT TO THE BACK TEETH ONLY; BUT WITH A SHORT PRESSING SWEEP FROM THE GUMS TO THE CUTTING EDGE OF THE TEETH. THUS THE STROKE IN THE UPPER JAW IS FROM THE GUM DOWNWARDS WHILE IN THE LOWER JAW IT IS FROM THE GUM UPWARDS. IN THE DIRECTION OF THE ARROWS IN DIAGRAM II.

USED ONCE A WEEK AN EXCELLENT ADJUNCT TO THE ABOVE AND A GREAT PROTECTION AGAINST DECAY OF THE TEETH CONSISTS IN SILKING, THAT IS, PASSING A STRAND OF SILK EIGHT OR TEN INCHES LONG, HELD TAUT BETWEEN THE INDEX FINGER AND THUMB OF EACH HAND - BETWEEN ALL THE TEETH AND DRAWING IT OUTWARDS FOR AN INCH IN SUCH A MANNER AS NOT TO HURT THE GUM. IF THE SILK IS CUT OR FRAYED IN PASSING BETWEEN THE TEETH, IT IS MOST LIKELY THAT DECAY IS PRESENT REQUIRING IMMEDIATE TREATMENT.

Fig. 14

carried out. The child's teeth should not be touched, but a small toothbrush should be given, and the result will soon be seen. When the child is handed over to the care of a nurse for the necessary ablutions, careful instructions should be given her that the same method of procedure shall be

adopted. It is necessary to add that whoever has the handling of a babe ought to have a clean and healthy mouth, free from all carious teeth and decaying roots of teeth. No mother should ever allow the child to be kissed on the lips or fondled by anyone with an unclean mouth. The dangers of septic contamination are not to be despised, especially in time of sickness, when the infant is most susceptible, and when sympathy is likely to take the form of kissing.

This illustration of method in cleanliness, simple as it may seem, not only involves a valuable habit, but a principle in teaching which it is desirable to remember.

In animals living under natural conditions the friction of food during mastication is sufficient to cleanse the teeth, and keep them clean, with the aid of abundant supplies of saliva. Why does this not suffice for healthy children? The natural method of cleansing presupposes food coarse enough to effect its purpose, and teeth strong enough to withstand disease. Many years' experience, both in Sheffield and London, has convinced the authors that British children have neither the one nor the other, and statistical evidence (referred to later) confirms the fact that there is a vast amount of disease in the first set of teeth which can only be partially prevented by habits of artificial cleanliness.

Nothing is more objectionable to a child than to have a cloth or a toothbrush put into its mouth. If, however, the parents will set the example, they awaken a desire, not to clean, truly, but to imitate. Such imitation leads to an invaluable habit, which, when early adopted, will seldom be abandoned. Example, we know, will tell for good or ill through life, but its influence in this particular instance may best be illustrated by its negative side. Never having seen its parents cleanse their teeth, morning, noon, or night, a child cannot understand that instructions to use a toothbrush are of any value. Consequently on every possible occasion its use is avoided and such instructions neglected until a child complains of pain. When, however, the whole household has been aroused in the night by the child with an exposed

tooth nerve or a swollen face (*vide* Chap. VI), followed by a visit to the dentist on the next day, and probably the loss of a valuable tooth, the parents are made aware of the fact that cleansing the teeth may help to prevent trouble in the future. So deplorable, however, is the ignorance upon such matters that even otherwise well-educated people will often say: "Why trouble about the first teeth at all?" not realizing the intimate connection between the first and the second set: that the first set are obviously intended for chewing food during a most important period of a child's life, and that everything which tends to destroy them interferes with the evolution of their successors.

The importance of cleansing the teeth will be more fully recognized after a perusal of Chap. VI; but example is, we repeat, the most valuable influence if this is to be carried out thoroughly and systematically by the child, for—

> "Example is the school of mankind, and they will learn at no other".[1]

[1] Burke.

CHAPTER V

THE SECOND OR PERMANENT DENTITION

Shedding of Temporary Teeth—The Emergence of the Permanent Teeth —The Order of their Appearance—Their Arrangement in the Jaws.

It has been stated (p. 41) that the crowns of the first temporary set of teeth are normally present in the mouth by the end of the second year, and that the roots are not completed until the fifth year or later. When these teeth are completed, a process is commenced by which the root of each is gradually absorbed or eaten away by bone cells and leucocytes, until both the roots and the bony sockets built up around them entirely disappear, unless interfered with by disease. The crowns of the teeth also become loose, and a very slight force is sufficient to remove them and make way for their successors. Each of these temporary teeth, on being shed, will be replaced by a tooth of the permanent series, and in addition there will be twelve molars, which come up behind, three on each side, above and below.

The first of the permanent teeth to make their appearance are the first molars, which should emerge above the gum, behind and next to the second temporary molars, about the sixth year, and before the temporary incisors disappear. This arrangement provides masticating surfaces at the back of the mouth whilst the temporary molars are being replaced by the bicuspids. On reference to figs. 15 and 16, these teeth—6, 6—will be seen in position behind E and D, the temporary molars. They are frequently mistaken for temporary teeth, and, when diseased, are neglected because

of this supposition; so much so that they are often partially or almost entirely destroyed before advice is sought. It is necessary to emphasize the fact that they come up *behind* and not in place of the temporary molars, because

A NORMAL DENTITION AT SEVEN YEARS

ve been removed for pain caused by den
it may be some time before the corr
is erupted, and thus a prolonged reducti
or mastication results.
the eighth year the lateral incisors will b
uccessors (as in fig. 16, B by 2). About
first temporary molars (D, D) will be re
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second temporary molars (E, E) will be
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ls and the first bicuspids. The crypts in
th are developed are placed side by side (4,
those of the canines (3, 3) are more deeply placed in the jaw,
so that any premature loss of the temporary canines allows
the permanent tooth on each side to approach the other, with
the result that the aftercoming permanent canines assume a
position outside the dental arch.
The anterior permanent teeth, at all events in the upper
jaw, are inclined somewhat obliquely forward, in lieu of

Fig. 15

these temporary molars are not naturally lost until some years later.

As, like the temporary set, the permanent teeth are still incomplete when the crowns appear through the gum, any obstruction caused by retained temporary teeth, or their roots, will easily direct the growth of the permanent teeth into a wrong position; and as the bone of the alveolar process is built up round the neck of the erupting tooth in whatever

situation it may assume, the completion of the root will perpetuate this irregularity, unless advice is sought of the dental surgeon in order that it may be rectified.

The actual shedding of the temporary teeth occurs about

A NORMAL DENTITION AT SEVEN YEARS

CHAPTER V

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Fig. 16

the seventh year, the incisors being lost first. This is shown in fig. 16, where the central (A) of the temporary set has disappeared from the lower jaw, to be replaced by its permanent successor, I, which is gradually coming into position. While the temporary teeth have been fulfilling their function, the permanent teeth have been developing behind them in the jaws, which have been increasing in size (figs. 15, 16). The result is that the temporary teeth, instead of remaining

shoulder to shoulder, now become separated (figs. 15, 16, at A, B), and are, so to speak, spread round the margin of the jaws. The spaces between the teeth are characteristic of the approaching change. On the loss by absorption of a temporary tooth its permanent successor is generally found ready to take its place, but in cases where the temporary molars have been removed for pain caused by dental disease —caries—it may be some time before the corresponding successor is erupted, and thus a prolonged reduction of the surfaces for mastication results.

About the eighth year the lateral incisors will be replaced by their successors (as in fig. 16, B by 2). About the ninth year the first temporary molars (D, D) will be replaced by the first bicuspids (4, 4). Between the tenth and twelfth years the second temporary molars (E, E) will be replaced by the second bicuspids (5, 5). The temporary canine teeth (C, C) should be the last of the milk dentition to disappear. They serve the useful purpose of preserving the necessary room for the permanent canines to take their places between the laterals and the first bicuspids. The crypts in which the latter teeth are developed are placed side by side (4, 2), whilst those of the canines (3, 3) are more deeply placed in the jaw, so that any premature loss of the temporary canines allows the permanent tooth on each side to approach the other, with the result that the aftercoming permanent canines assume a position outside the dental arch.

The anterior permanent teeth, at all events in the upper jaw, are inclined somewhat obliquely forward, in lieu of taking a vertical position as did the temporary ones. This spreading arrangement allows the larger crowns of the permanent teeth to adapt themselves round a segment of a larger circle at the front of the jaws, the canines also sharing normally in the regularity of position, side by side with the neighbouring teeth.

Further, a careful inspection of fig. 16 not only shows the salient points in the eruption of the second set, or permanent dentition, but will bring more clearly to the mind the

necessity for keeping the first set in a thoroughly healthy condition until, their functions being fulfilled, they pass away.

A NORMAL ADULT DENTITION

FIG. I.

FIG. I

THE PERMANENT TEETH.

1. CENTRAL } INCISORS.
2. LATERAL } INCISORS.
3. CANINE.
4. 1st } PREMOLARS.
5. 2nd } PREMOLARS.
6. 1st OR 6 YEAR } MOLAR.
7. 2nd OR 12 YEAR } MOLAR.
8. 3rd MOLAR OR WISDOM TOOTH.

FIG. II.

FIG. II.

SHOWS HOW THE UPPER TEETH ARTICULATE WITH THE LOWER ONES.

FIG. III.

USUAL AGE AT WHICH THE VARIOUS TEETH APPEAR THROUGH THE GUM.

YEARS	6	7	8 to 9	10	11	12	13	18 to 25
TEETH	6	1	2	4	5	7	3	8

Fig. 17

At 7 the crown of the permanent molar is seen buried in the jaw.

Fig. 17 shows the arrangement of the permanent teeth in a normal adult. About the twelfth year the second permanent molars (7, 7) will appear behind the first permanent molars (6, 6). Between twelve and thirteen years of age the permanent canines (3, 3) will take their places in the

jaws on the disappearance of the last of the temporary series (*vide* fig. 16).

Between sixteen and twenty-four years of age the wisdom teeth, or last molars (8, 8), will appear behind the twelve-year molars (7, 7), and thus complete the eruption of the permanent series. The emergence of the wisdom teeth is often accompanied with some reflex irritation and pain, owing to the overcrowded condition of small jaws.

It should be noted that when the teeth are closed each molar and bicuspid articulates with two teeth, the front teeth of the upper jaw overlapping the front teeth of the lower jaw.

CHAPTER VI

DENTAL DISEASE—THE DESTRUCTION OF THE TEETH

Bacteria--Many Kinds—Mouth Bacteria—Their Cultivation—Action on Food—Fermentation—Acid-forming Bacteria—Effects upon the Teeth Tissues—Destruction of Enamel—Invasion and Destruction of Dentine—Exposure of the Pulp—Death of the Pulp—Formation of Septic Material—Tissue Effects.

Many diseases with which we are more or less familiar are caused by the action of organisms of vegetable origin. They have enormous powers of multiplication, and are so minute that they are only to be seen microscopically, and then only by special methods of staining. They form part of an innumerable host called bacteria, belonging to the group of fungi. They are unicellular plants, and contain no chlorophyll. Only within recent years are we gaining a clearer knowledge of their life-history, and that by methods of cultivation outside the human body. Some bacteria are as useful to mankind as others are harmful, and both kinds are found in the air, the water, and the soil. Those which are useful to mankind are known as *saprophytic*, and find their nourishment in decomposing vegetable and animal matter; while the harmful, known as *pathogenic*, or disease-producing, grow, multiply, and thrive on living tissue. Many bacteria gain entrance to the body through the skin, such as those which produce tetanus and hydrophobia, but a much greater number through the mouth, finding their way to the various tissues of the body, which, under certain conditions, become a suitable environment for their multiplication and the exercise of their malign influence. The tubercle bacillus

is a type of such bacteria. It destroys a vast number of lives every year in this country.

The late Professor Miller obtained and cultivated a hundred different kinds of bacteria from the mouth,[1] some saprophytic and many pathogenic. To him we owe much of our present knowledge of dental caries. That condition is accountable for the largest proportion of dental diseases, and results in the destruction of the hard tissues of a tooth. Dental caries invariably attacks the external aspect of the tooth, and is entirely due to outside agents.

But for the facts mentioned in Chap. II it would be difficult to understand why teeth—the hardest structures in the human body—can be destroyed. The effect of weak acids, however—first on the enamel covering and then on the dental tissues, which owe their density to the lime salts deposited during the process of development—is, as previously stated, to dissolve the lime, leaving only a gelatinous matrix. Such acids are constantly found in the mouth, and although the secretion from the mucous membrane of the gums is sometimes slightly acid, yet in conditions of health this acid secretion is neutralized at once by the constant flow of saliva from the salivary glands. Where, however, the mouth is in an unhealthy condition, it is not at all uncommon to find the saliva acid, and then we have an important factor in the production of caries.

The principal source from which acids are formed in the mouth is found to be particles of food remaining in the neighbourhood of the gums and teeth, or, in brief, on those surfaces which the tongue does not sweep. In such positions the retained food undergoes fermentative changes.

It is a well-established fact that to bacteria we owe such processes as fermentation. In order that these may be carried out successfully suitable material is necessary, and also a chamber kept constantly moist, at a sufficiently high temperature, with free access to the air. The mouth is such a chamber, and an ideal one, with all the conditions favour-

[1] Tome's *Dental Surgery*, p. 203.

able for the action and propagation of micro-organisms; and the particles left upon or in the neighbourhood of the teeth are the material essential for their cultivation. The production of caries in teeth depends entirely upon the presence of micro-organisms or bacteria in the mouth, and among those isolated and cultivated by Miller, as above referred to, twelve were characterized by the formation of lactic acid.

The process which results in the loss of a tooth by decay or caries has two stages. In the first, the protective covering of enamel is affected to such an extent that the dentine beneath becomes accessible. Then ensues the second stage, in which sufficient destruction of the dentine takes place to subject the nerve tissue and blood vessels in the centre of the tooth to irritation and subsequent inflammation. The amount of tissue destroyed and the rate at which the process progresses vary in individual cases, whilst the age of the tooth, and the consequent size and condition of the pulp, also influence the course of the disease. The activity of the agents concerned is modified by the changes in their environment or life relations, brought about by local hygienic conditions, and also by the extent to which the tissues involved are well or badly developed.

The action of bacteria upon particles of food retained in the fissures and interstices of the teeth, especially the carbohydrates, which are converted into some form of sugar by ptyalin, the active principle of saliva, results in fermentation and the production of acid, and when this has been frequently enough renewed to allow of its remaining sufficiently long in contact with the enamel, the lime salts in the tissue are dissolved, and a nidus is formed in which the bacteria and sugar are even better protected, and in which the fermentative process can proceed still more rapidly (fig. 22, I, A).

When the process of decalcification has brought the dentine within range, the bacteria are able to travel along the dentinal tubules and to extend the destructive action into the surrounding tissue.

In the dentine three different processes, which seem to be

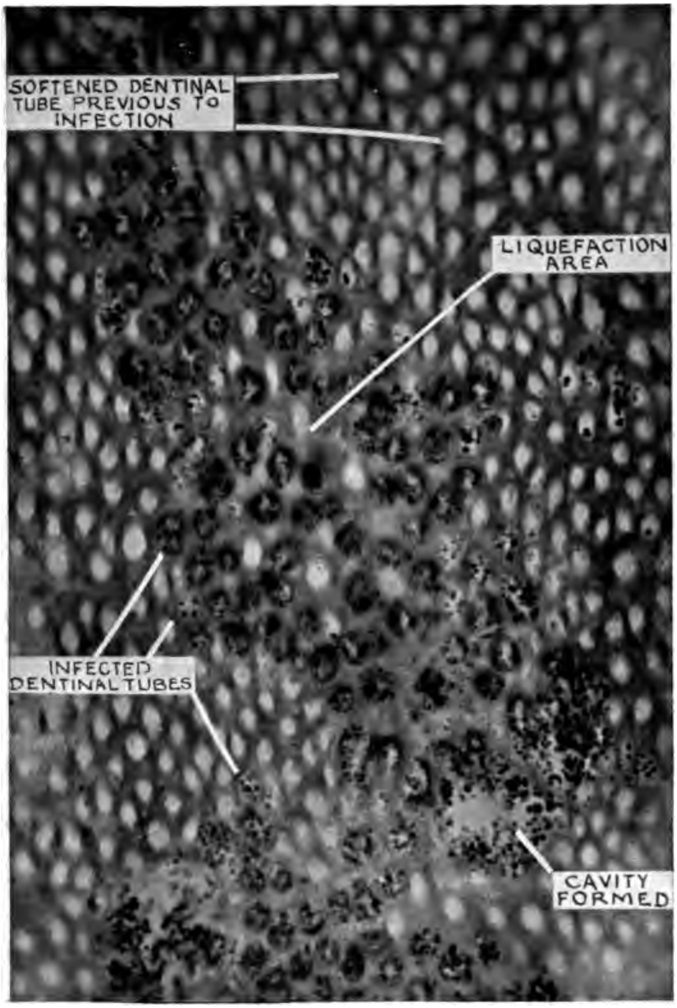


Fig. 18.—Transverse Section of Carious Dentine. × 750

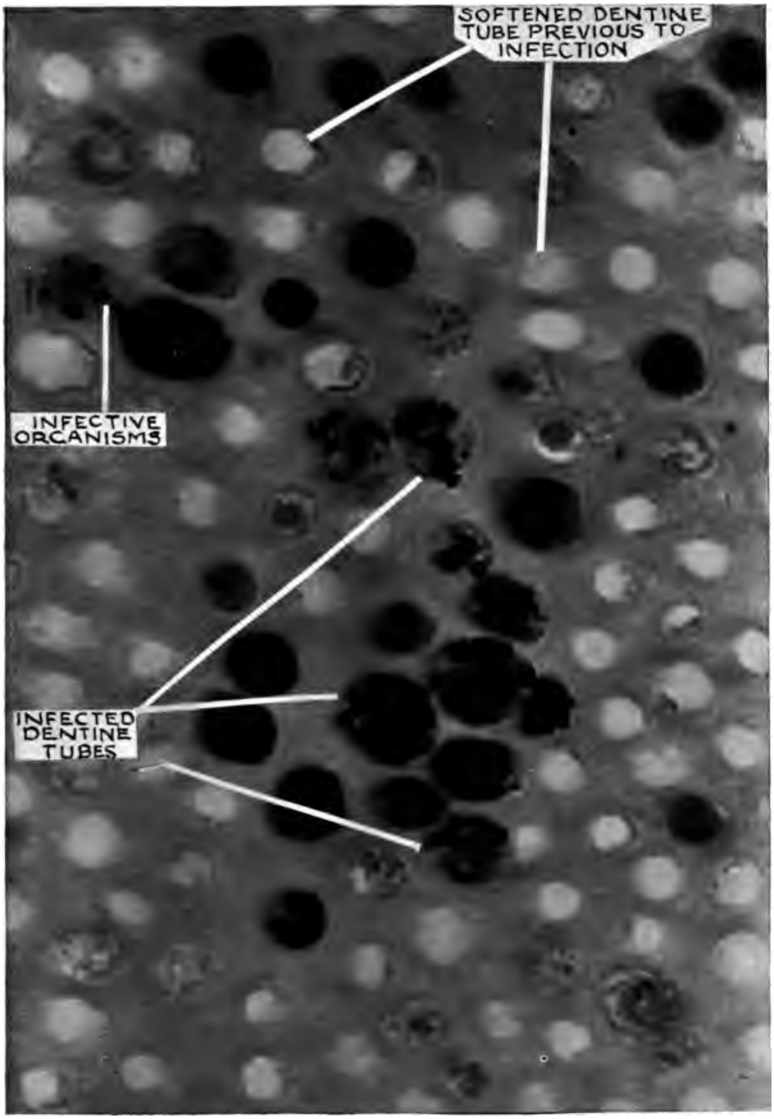


Fig. 19.—Transverse Section of Carious Dentine. × 2250

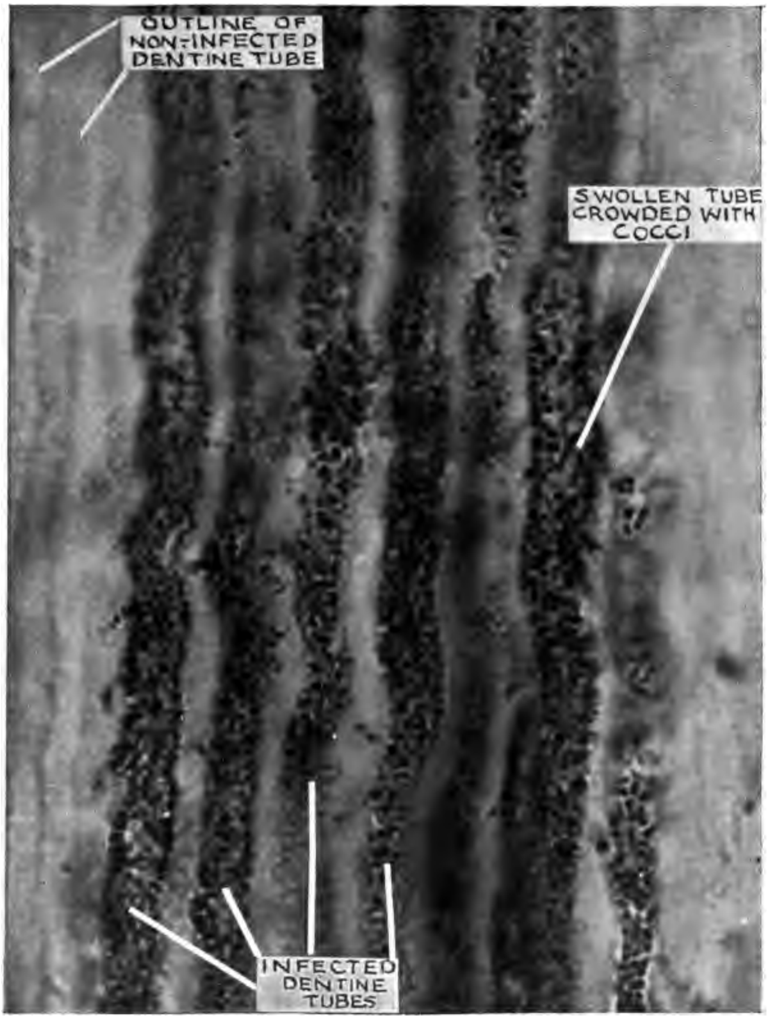


Fig. 20.—Longitudinal Section of Carious Dentine. × 2250

simultaneous, are recognized as being due to different organisms:—

1. Decalcification or removal of the lime salts due to acid-producing bacteria.
2. Digestion of the gelatinous matrix by bacteria which liquefy decalcified dentine.
3. Pigmentation or discoloration of the tissues involved.[1]

As the enamel consists mostly of lime salts, the acid-forming bacteria are chiefly concerned.

Sections prepared and stained for microscopical investigations throw a very clear light on this action of bacteria. Fig. 18 is a transverse section through a piece of carious dentine magnified 750 times. This has been decalcified by acid-forming bacteria. In patches above and below are open dentinal tubules, oval or circular in shape, having a ground-glass appearance and surrounded by a gelatinous matrix. In several of these spots are seen, evidently due to the presence of micro-organisms. A large patch in the centre shows infection of the tubes *en masse* with the matrix surrounding them, the whole tissue is undergoing decomposition, and below in two places liquefaction is taking place with the formation of a cavity. Fig. 19 is a small portion of fig. 18 more highly magnified. Infection, with enlargement of the open tubes, is there evident, with destruction of the gelatinous matrix.

The condition of carious dentine is more clearly seen in longitudinal sections, where it is not only possible to identify the infection of individual tubes, but to recognize the forms of the bacteria which are carrying out the destruction of the tissue. Fig. 20 is a section of carious dentine magnified 2250 times. In the centre the tubules are swollen and beaded in outline, and are full of micro-organisms. These latter belong to the order of cocci, groups of small round cells described, when single, as *micrococci*, when in pairs, *diplococci*, and when

[1] Goadby: *Mycology of the Mouth.*

twisted, *streptococci.* The whole tissue is undergoing dissolution.

In fig. 21 an outline of the tubules is seen on each side. In the centre the infection is so extensive that it is scarcely

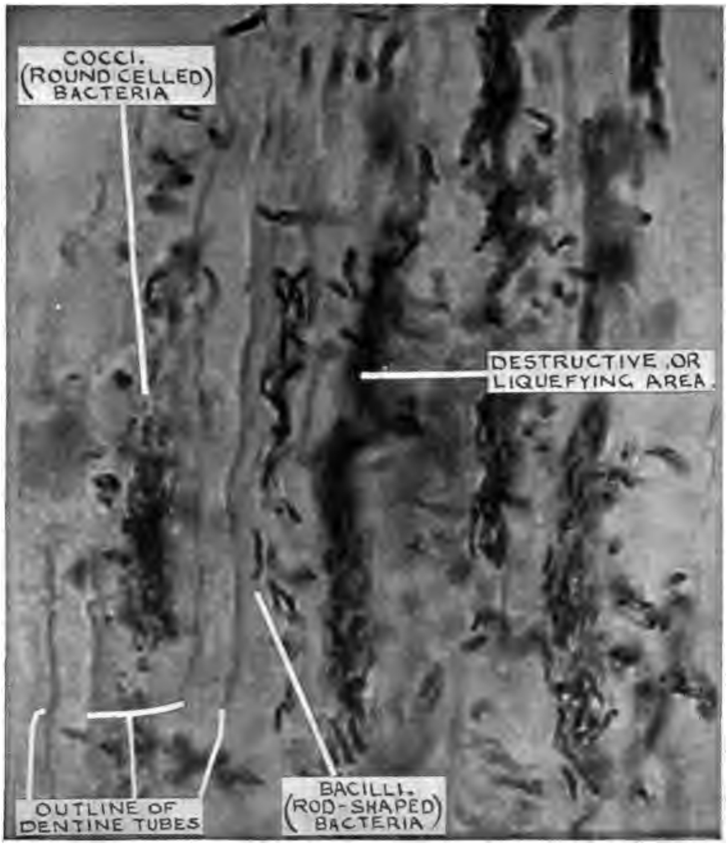


Fig. 21.—Longitudinal Section of Carious Dentine. × 2250

possible to distinguish between the tubes and the matrix outside them. The infection is a mixed one, consisting for the most part of rod-shaped bacilli and of cocci. Dissolution with liquefaction of the whole tissue is in active progress.

Owing to the exposed condition of the teeth the physical signs of caries or decay are easily observed, and reference to the following diagrammatic representations of the progressive stages of tooth destruction will enable the reader

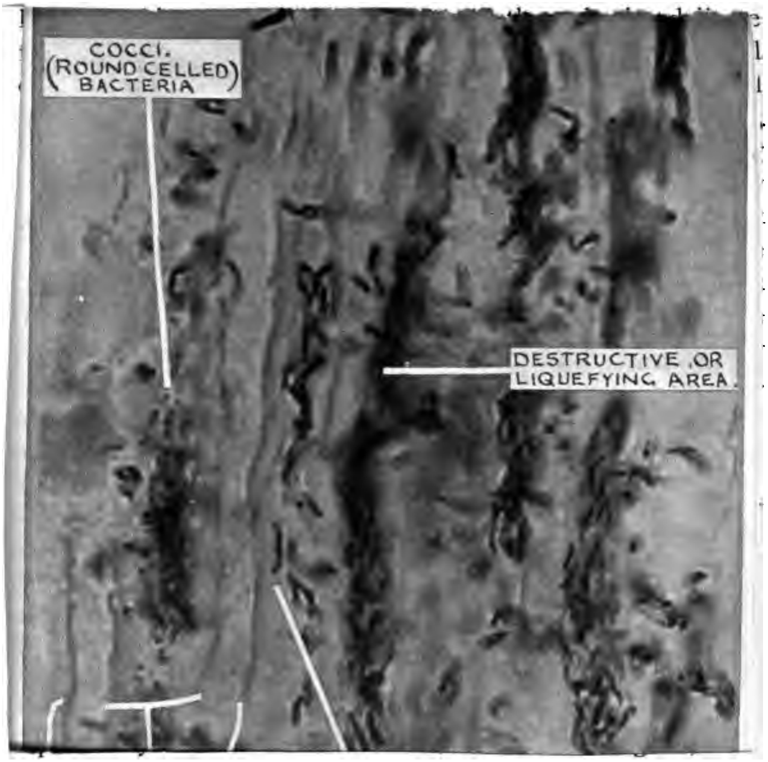
al bacteria, yet, should any remain in the cavity, their activity s reduced to a minimum, as, having neither moisture nor air, hey become inert. Where treatment is neglected another stage in the destruction of a tooth is sooner or later reached; nore of the enamel is broken away (fig. 22, III), the softening and liquefaction of the dentine extend to the pulp chamber, which becomes infected by bacteria, and the delicate nerve tissue becomes irritated and the blood vessels inflamed. The pressure caused by mastication breaking down the disintegrated enamel and exposing a large surface of carious dentine may also cause intense pain. The infection of the pulp alone, where there is no outside pressure, often results in acute pain, in agonizing paroxysms, increasing at night time and lasting from a few hours to days or sometimes weeks; and where a cavity exists at the side of a tooth, free from the pressure of mastication, it is often impossible at once to localize the pain. Owing to the intimate connection of one tooth with another, each nerve being linked up with its fellows (*vide* p. 18), the pain may be diffused over a wide area on one side of the face and the jaws. When localized, this pain is spoken of as "toothache", or odontalgia, and it is in this condition that the sufferer often seeks relief by insisting upon the immediate removal of the tooth. When

Fig. 22

to recognize not only the results of such destruction, but the necessity for treatment in the early stages.

A typical tooth has been chosen, that of a premolar or bicuspid with a single root. The sections of it are vertical, and show the whole tooth with the surrounding tissues *in situ*. The first change is seen in the enamel (fig. 22, I, A), which loses its semi-translucent appearance at one spot, and

is discoloured and rough, the colour varying from white to a darkish brown. The tissue is porous and can easily be perforated by a steel point, or cut into with a fine chisel. It is at this stage, when the dentine has been laid bare, that transient irritation from solutions of salt or sugar, or from



the dentine is of a brownish colour, reduced in quantity and burnished. The pain or discomfort from a carious tooth, when much of the dentine is destroyed, varies in individual cases; it may be absent, it may be transient, or it may be sufficient to cause slight inflammation in the blood vessels of the pulp chamber and those which surround the tooth in its socket. It is, however, at this stage that the remedial art of filling a tooth is attended with the best results. The careful removal of carious dentine by suitable instruments, the protection of

that portion of the dentine nearest the pulp chamber with a non-conducting layer of cement, so that the nerve irritation is prevented, and the complete filling of the cavity with a suitable stopping, will often preserve the tooth and render it useful for many years, and although it may not be possible to remove all bacteria, yet, should any remain in the cavity, their activity is reduced to a minimum, as, having neither moisture nor air, they become inert. Where treatment is neglected another stage in the destruction of a tooth is sooner or later reached; more of the enamel is broken away (fig. 22, III), the softening and liquefaction of the dentine extend to the pulp chamber, which becomes infected by bacteria, and the delicate nerve tissue becomes irritated and the blood vessels inflamed. The pressure caused by mastication breaking down the disintegrated enamel and exposing a large surface of carious dentine may also cause intense pain. The infection of the pulp alone, where there is no outside pressure, often results in acute pain, in agonizing paroxysms, increasing at night time and lasting from a few hours to days or sometimes weeks; and where a cavity exists at the side of a tooth, free from the pressure of mastication, it is often impossible at once to localize the pain. Owing to the intimate connection of one tooth with another, each nerve being linked up with its fellows (*vide* p. 18), the pain may be diffused over a wide area on one side of the face and the jaws. When localized, this pain is spoken of as "toothache", or odontalgia, and it is in this condition that the sufferer often seeks relief by insisting upon the immediate removal of the tooth. When the pain is diffused over a wide area the patient may be said to be suffering from neuralgia, a word constantly used as the name of a disease instead of a symptom of a *cause* to be sought out and remedied. When we remember that circulation of the blood is taking place in the pulp chamber, through the vessels which enter the apex of the root, the intolerable pain is readily accounted for. The irritation, caused by exposure to the bacteria and fluids of the mouth, induces an increased supply of blood to be forced into the tooth, con-

sequently the nerve tissue is subjected to greater pressure. Now as both nerve tissue and blood vessels are confined within bony walls, there is no possibility of expansion, and the result, sooner or later, is the strangulation of blood vessels and nerves; in other words, the pulp dies and all pain ceases. When, however, the pulp of a temporary tooth has been exposed by caries, it is better to remove the tooth at once. In a permanent tooth every endeavour should be made to save it, and in most cases this can be effectually carried out by destroying the exposed nerve with the aid of local anæsthetics. When this is accomplished the necrotic tissue is removed, antiseptic fillings are introduced into the pulp chamber and into as much of the root as is possible, the lost dentine and enamel are replaced by suitable fillings, and the tooth may be restored to active service for some years. It cannot, however, be too forcibly insisted upon that *when a tooth has once ached for any lengthy period, and thus shown that the pulp is involved, the most suitable time for saving that tooth has passed away.* From the dentist's point of view stopping a tooth does not mean only causing the pain to cease. It means restoring the lost dentine and enamel, and this, if possible, before the nerve is exposed.

When the contents of a pulp chamber are destroyed a tooth loses half its nourishment; the root is supplied thenceforth by the blood vessels which line the socket, and all nourishment is removed from the crown.

The death of the nerve tissues and blood vessels is followed by their decomposition and putrefaction, and the once living tissue is converted into a mass of septic material which extends to the end of the root. This may remain quiescent for a time, but it is in a chamber in which bacteria of all kinds may grow and their products become mixed with the food and swallowed. The pressure of mastication or the blocking of the open canal sooner or later, however, prevents the free escape of the products of decomposition into the mouth. The septic material is then forced through the root into the surrounding tissue (fig. 22, IV). This may be

for the carious tooth, but for the neighbouring teeth on the same side of the mouth, and the debris of food collects on the affected side, and affords extra pabulum for the reproduction of bacteria. In addition, lime salts from the saliva, in which particles of food are entangled, are deposited round the necks of the teeth, the gum margins become irritated and inflamed, and, when ulcerated, form centres of infection. Even artificial cleansing is avoided, and, further, the proper mastication of food is impaired; material for the destruction of other teeth accumulates, the breath becomes offensive, and the health suffers.

The constitutional effects of defective teeth will be considered later, but a fitting conclusion to this chapter may be found in the following brief *resumé* of the salient facts of dental caries, which will be rendered clear by reference to fig. 23 (a diagrammatic representation of a tooth in transverse section at the level of the pulp chamber), viz.:—

1. Dental caries always commences on the outside, and is due to external causes.

2. Fermentation and putrefaction of particles of food are effected by bacteria ever present in the mouth, with the production of acids. These are aided by warmth, moisture, and exposure to the air.

3. The enamel is attacked at one spot, some places being more vulnerable than others, especially in crevices where food has the opportunity of resting.

4. The enamel prisms are split up and disintegrated. When the dentine is reached the acid-forming bacteria dissolve out the lime and leave a softened area.

5. The dentinal tubules are invaded, and they become swollen and dilated.

6. Liquefying bacteria dissolve the tubes and the gelatinous matrix.

7. Further disintegration of enamel, with dissolution of the dentine, leads to the formation of a cavity, in which food and bacteria find a resting place.

8. Gradually the pulp is infected.

9. Owing to inflammatory action the nerve tissue is irritated, the blood pressure is increased, and the vessels become dilated.

10. Pus appears in isolated spots, and the whole tissue dies.

11. This is followed by decomposition and putrefaction.

12. When this septic material is forced through the root an abscess is the result, accompanied with fever and general *malaise*.

CHAPTER VII

THE RELATIONSHIP BETWEEN DENTAL AND OTHER DISEASES

Bacterial Infection and Immunity—Bacteria in the Body—Resistance to Bacteria—Protective action of the Blood and Tissues—Resistance to Bacteria by the Teeth contrasted with that of other Tissues of the Body—Infection of the Jaws—Constitutional Effects of Bacteria from the Mouth.

When describing the action of bacteria upon the teeth the local effects have been considered. It is, however, essential to point out certain constitutional diseases which may be caused by the accumulation and cultivation of bacteria in the mouth, and by the subsequent bacterial infection.

Although it may not at first sight be easy to understand how, as the result of carious teeth, a child or an adult may suffer from pneumonia or tuberculosis, or from pyæmia or appendicitis, such results of carious teeth can easily be explained.

That there is a relationship between dental and other diseases may be inferred from these facts:—

1. The structure of the body—including the teeth—is entirely cellular (p. 20), and so intimately are the various component tissues interrelated that it is almost impossible for one to suffer without the whole being more or less affected.
2. A vast number of diseases, including those of the teeth, are of bacterial origin.

The tardy recognition of the latter fact, and the peculiarity

of the dental tissues in form and structure, have obscured this kinship, so much so that it is only now beginning to be realized. The connection may best be shown by reference to the action of bacteria upon the body generally, and the means by which the body protects itself against their action.

Pathogenic or disease-producing bacteria are often likened to the seed, and the human body to the soil. The simile is trite, and if we take tubercle bacilli as an example of such organisms, we know that they will grow and flourish in certain persons, while in others they have no apparent effect. Some are susceptible to their ravages, and others are relatively insusceptible or immune. This natural partial immunity from tuberculosis or consumption is found particularly in people with healthy constitutions. Susceptible persons have inherited a predisposition for disease, *i.e.* they are the suitable soil for it; or, owing to environment, their resistance to disease has been weakened by vitiated air, by deficiency of food, by alcoholic excess, or by previous disease. As an example of the influence of previous disease in favouring further disease, especially of one bacterial infection preparing the way for others, influenza may be cited. Influenza is an infectious disease having a bacterial origin. It comes in epidemics, and attacks those who appear to be in the best of health. After an attack of influenza the resistance to infection may be so weakened as to render the patient liable to attacks by many different bacteria, of which the tubercle bacillus and the pneumococcus of pneumonia are the most common.

Immunity from certain infectious diseases presumably due to bacteria may be acquired. For instance, those who have suffered from scarlet fever, measles, smallpox, &c., seldom have another attack of the same disease, and this is due to the protective action of the blood, which will be referred to later. In tuberculosis no such protection is conferred by attack, and in dental caries the same remark applies. The best protection against such diseases is a sound and healthy constitution.

> "Bacteria are never more than primary causes, for the nature of disease, as Virchow said, *depends upon the behaviour of the organs and tissues with which the bacteria or their products meet*."[1]

It should never be lost sight of that certain bacteria are always present in the human body. They swarm in the whole of the alimentary canal, and are to be found in great numbers in the respiratory organs. Like the poor, they are always with us, and their presence appears to be a necessity of our existence; but there are some—comparatively few in number—which thrive upon, and at the expense of, their host. Further, they have their favourite haunts. Those of tuberculosis flourish mostly in the lungs; of diphtheria, in the throat; of tetanus, in abrasions or wounds of the skin. Some thrive first in other living creatures before being introduced into the human body, perhaps the best example being that of plague, which is spread by rats and fleas.

In a healthy subject the skin and the mucous membrane lining the alimentary canal and the respiratory organs may be regarded as germ proof. They are being constantly renewed by cell growth from their deeper layers, and are aided in their resistance to the invasion of bacteria by secretions which flow from their surfaces. An additional protection is afforded to the alimentary canal by the saliva, gastric juice, bile, &c., aids to digestion, which flow from the glands secreting them.

When bacteria obtain an entrance their action, broadly speaking, is twofold: (1) they induce disease by invading the tissues and setting up inflammation; or (2) their toxins pass into the blood stream direct, and produce symptoms of general poisoning. A period known as "the incubation period" elapses between the time of infection and the onset of symptoms, varying from a few hours to two or three weeks.

The resistance to the invasion of bacteria by the tissues is

[1] George Newman, M.D.: *The Health of the State*, p. 73.

shown in various ways. Inflammation is one of nature's chief methods of protection. In the characteristic changes of the tissues affected by inflammation the white corpuscles or leucocytes of the blood bear an important part. These leucocytes (fig. 24)[1], which have been newly formed in lymphatic glands, change their shape and pass through the walls

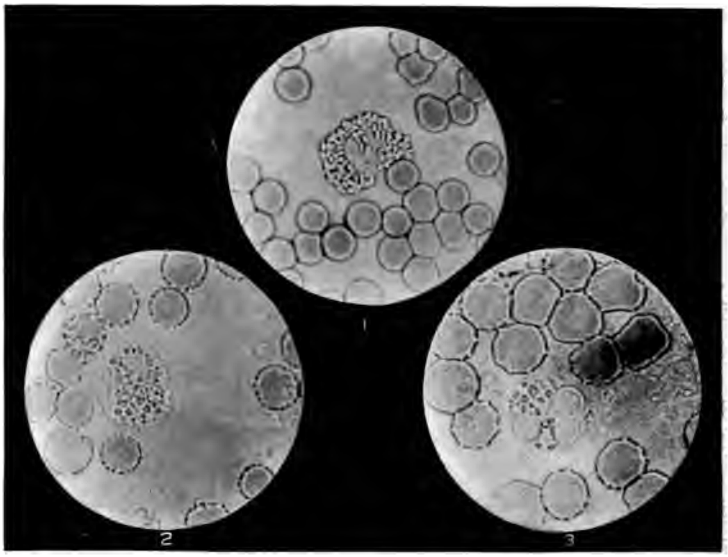


Fig. 24.—White Corpuscles or Leucocytes of a Cat (Sherrington)

of the finer blood tubes (p. 14). They are tissue excavators, builders, repairers, and under certain conditions of the blood have the power to digest bacteria. In these circumstances they are described as phagocytes.

The roots of the temporary teeth, when healthy, are eaten away by leucocytes, so that only their crowns remain, to be removed by the slightest force (p. 52). Should a small portion of tissue die, the leucocytes are frequently able to absorb it. If this is impossible, they will separate it from the living

[1] By permission of Professor Sherrington, F.R.S., and the Royal Society.

tissue. By these means nature often endeavours to get rid of dead roots of teeth.

When teeth are taken from the jaws the leucocytes remove the bone in which they were embedded; this explains the so-called shrinking of the gum.

Should a splinter of wood or glass be forced into the skin, the leucocytes at once attack it. If small and clean they will form a fibrous tissue round it, thus rendering it harmless. If the foreign body be accompanied by dirt or dust, the tissues swell, pus is formed from the leucocytes which have been destroyed in the attack, and with the exit of the pus the foreign body is discharged, and fresh leucocytes heal the wound.

The teeth, as evidenced by their structure, are a specialized form of skin, and the amount of dental caries in civilized communities seems to prove that the susceptibility of the teeth to bacterial attack is very great, for the enamel, the only part of a tooth exposed to the influence of bacteria, is not sufficiently sound to withstand destruction. The reasons for this have been previously explained, but it should be mentioned that both enamel and dentine are passive agents when attacked, as no circulation of blood takes place in their structures. A post-mortem examination of a tooth shows, in some instances, that an attempt to resist the approach of caries is manifested by an increased activity of the dentine-forming function of the pulp, a barrier of calcified tissue being found constructed at that portion of the pulp chamber which is nearest to the cavity; but in the vast majority of teeth, infection seems to give no time for such resistance.

Inflammation of the pulp is nature's effort to overcome the intrusion of bacteria and their toxins, but here the tissues have insuperable difficulties. The narrowness of the orifice at the apex of the root, through which the blood circulates, and the impossibility of expansion, as in soft tissues elsewhere, limit and finally block the increasing supply of blood forced into the tooth, with the result that the pulp gradually dies. Thus what in other structures is a principal means of

preservation is in this case only an agency of destruction. Outside the tooth, in the porous bone, however, the circulation of the blood is comparatively free, and here the exudation of blood plasma and leucocytes enables the latter to build new tissue at the apex of the root. The dead pulp undergoes putrid decomposition, aided by the organisms which originally infected it, and many more which have found a home in the pulp chamber. It is therefore now only a question of time when nature will seek to be rid of the tooth. Embedded in the tissues of the jaw, it becomes a foreign body, but unique of its kind, as reference to fig. 22 IV will show. Having a funnel-shaped opening above, through which it receives fresh supplies, and a narrow canal throughout its length, it is filled with bacteria and their toxins. For this no parallel is found, except it be that of a serpent's tooth, down the centre of which, to its pointed extremity, runs a narrow canal, through which a virulent poison is forced into the body of its victim.

As previously explained, the infection of the jaws *via* the teeth is aided by the pressure of mastication (p. 72) and the blocking of the funnel-shaped opening. When this occurs, and septic material and bacteria are forced into the tissues, the extent of the inflammation will depend upon their virulence. A rush of blood to the affected part occurs, followed by dilation of the blood vessels and the pouring of blood plasma and leucocytes into the tissues. The bacterial toxins will destroy a certain amount of tissue and leucocytes, hence the formation of pus and the expansion of bone. Protective tissue is formed behind the abscess, and continues to be formed until the pus has made its way out through the jaw or gums, and finally protective tissue lines the narrow canal —a sinus—through which pus oozes on to the surface (fig. 22, IV, c).

When the toxins pass direct into the blood stream, protective fluids or *antitoxins* are produced by the blood, which have the power, under favourable circumstances, of neutralizing their action. If bacteria alone enter the tissues from

the tooth their toxins combine with the lymph, or blood plasma, in which the bacteria are bathed, and from this fluid portion of the blood, protective substances—antibacterial—are formed, which not only neutralize the bacterial poisons, but enable the leucocytes or phagocytes to digest the bacteria. These protective substances are described as *opsonins*, and the absorption or digestion of bacteria *phagocytosis*.

When the jaws are infected from a necrotic or dead tooth the above processes are intermingled, and mixed infections occur owing to the presence of different kinds of bacteria. Sometimes one feature predominates, sometimes another. It is, however, well recognized that when once these bacteria are introduced into the tissues direct, even death may occur through general blood-poisoning, pyæmia and septicæmia.[1]

It is through such teeth as we have described that the tubercle bacilli may find their way through the lymph canals to the nearest lymphatic glands in the neck, infect them, and spread to other glands in the body.

It is not unusual to find several teeth in this septic condition in the mouths of both young children and adults. The fœtid breath, the sallow complexion, and the general debility are unmistakable evidences of the general effects of such septic infection. If to these be added the inability to masticate food, and the nervous irritation caused by carious teeth, we have important factors in the production of many diseases, especially of those in which the lowering of bodily resistance to bacterial invasion is of great importance.

The accumulation of bacteria and their poisonous products are very detrimental to the surrounding tissues. The mucous membrane of the mouth is often affected, and the chronic inflammation of the tonsils accompanied by gradual enlargement shows the bacterial attacks upon the protective tissues in the throat.

The contents of carious and necrotic teeth, with small quantities of pus discharged on the gum, are churned up and swallowed with every meal. The stomach may success-

[1] Sims Woodhead: *Bacteria and their Products*, p. 343 *et seq.*

fully resist them for a time, but they are often absorbed into the system, and produce symptoms of poisoning, made evident by an abnormal temperature, with anæmia, or with gastric and intestinal catarrh.

The tubercle bacillus and the pneumococcus are frequent inhabitants of healthy mouths.[1] It is under such conditions as we have described, when the general health has been gradually impaired, that these organisms find their way into the lungs, producing consumption or pneumonia, or by invading the alimentary canal, cause gastritis or appendicitis.

Only the fear of burdening these pages with details prevents the publication of many cases in illustration of the above statements, gleaned both from personal observation and from the medical literature of the past few years.

[1] "The Pyogenic Activities of the Pneumococcus," Dr. J. W. H. Eyre, *The Lancet*, Feb. 22, 1908, p. 539 *et seq.*

CHAPTER VIII

PAST, PRESENT, AND FUTURE OF DENTAL DISEASE PREVENTION AND TREATMENT

Dental Disease in the Past—Present Conditions—Systematic Examination—Systematic Treatment—Results—Medical Inspection Act—The Future—Summary.

Each individual is, or ought to be, guided in his conduct under present conditions by his past experience. The wise man will add to his own experience that of others, in order to avoid the pitfalls with which inexperience is beset. This is especially true in regard to the material issues of life and death, and particularly to the prevention of disease.

Bacteriology has altered our whole conception of disease within recent years, and of necessity it has largely altered the methods of treatment.

The treatment of diseases by certain drugs, the utility of which has not been proved, is steadily diminishing, and we are coming to recognize more clearly that science must be our guide in life. The work of men like Pasteur, Lister, and Koch has shown that while we are undoubtedly born to die as surely as we are born to live, we need not die of bacterial disease.

The above general considerations lead us to a brief enquiry in this concluding chapter into certain general aspects of dental diseases, which have an intimate bearing on their prevention.

The records of the past are indelibly written on the jaws and teeth of ancient skulls, which now find a repository in

our public museums. They have been carefully examined, and the results are at our disposal.

The most valuable investigation, extending over a series of years, was that of the late Mr. Mummery, who examined 3000 skulls, 1658 of which were tabulated.[1] An epitome of his results is contained in the following table:—

Race.	Percentage of Skulls in which one or more Carious Teeth were found.
1. Ancient Britons	20.1
2. Anglo-Saxons	15.8
3. Romans	28.6
4. Egyptian Mummies	33.3
5. Native Americans	15.5
6. Australasians	
7. Polynesian	
8. African	
9. Asian	

From such investigation we recognize the presence of dental disease in all ages and races of the past. The higher percentage of diseased teeth of the Egyptians and the Romans seems to point to the effects of a high civilization, with its accompaniment of luxury.

Much valuable information is also given in the Report of the Interdepartmental Committee on Physical Deterioration.

The Hygiene Committee of the British Dental Association examined the collection of British skulls in the Museum of the Royal College of Surgeons of England.[2] They state that "Dental caries in skulls of ancient date was almost entirely absent, and where present it was trifling in extent. Skulls of modern date showed evidence of dental caries to a considerable extent." They also state that "no comparative statistics as to the prevalence of dental caries have been found".

In the absence of such evidence there is a well-founded belief that modern Western civilization has brought in its

[1] *Transactions of the Odontological Society, 1870.* [2] Vol. III, p. 99.

train a marked increase in dental caries. This belief is confirmed quite independently of the dental profession. Professor Cunningham, F.R.S., in his evidence before the Interdepartmental Committee on Physical Deterioration, was asked: "From your experience as an anatomist have you noted any changes in structure unfavourable to development?" He said: "No, I have not, except in the one case of the teeth. In other directions I think I might almost say there has been an improvement; but there is no doubt about the teeth. It is an obvious fact that the teeth of the people at the present time cannot stand comparison in point of durability with those of the earlier inhabitants of Britain. Those who have the opportunity of examining ancient skulls cannot fail to be struck with this. In such skulls it is common to notice the teeth much worn down, through the coarse and gritty character of the food used in these early times, but still they are usually firmly implanted in the bony sockets of the jaws."[1]

Professor Cunningham attributes this deterioration of tooth tissue indirectly to the shortening of the jaw and the overcrowding of the teeth, and therefore to their greater liability to disease; but he says: "The real cause of this degeneration is the striking change which has taken place in the character of the food".[2]

How far dental disease has increased during recent years statistical evidence does not show. That there has been a marked increase many believe, but Dr. Newsholme, after an exhaustive examination of the recruiting statistics of the British army so far as they bear on the question of the condition of the teeth of recruits, states that "the increased number of rejections for defective teeth from 1897 onwards is probably due, in part, to increased stringency of examination, and still more to the fact that a large number of men presented themselves of an inferior class to those previously examined. On the whole the figures detailed do not, in my opinion, justify the conclusion that there is now a worse con-

[1] and [2] Vol. II, pp. 97, 98.

dition of the national teeth than forty years ago. . . . They indicate clearly, however, the importance of dental caries from a military standpoint, and the need for national action in the prevention of this disease in the interest of an efficient army as well as in the interest of the public health."[1]

Whatever opinions may be held as to the relative increase of dental disease, we have unmistakable evidence of its prevalence, not only by the number of rejections among army recruits, but in the fact that "more than 3000 men were invalided home during the Boer War on account of defective teeth. This, however, did not fully represent the extent of dental disease, as the Government sent out several dentists to attend to the troops in the fields, besides employing the services of many local dentists for those at the base."[2]

The extent to which dental disease is prevalent among children is seen by the statistics obtained by the Schools Committee of the British Dental Association.

The following table shows the results of an examination of the mouths of 10,517 boys and girls in English and Scotch schools, with an average age of about twelve years:—

Number of children examined ...	10,517		
Temporary teeth requiring filling		9573	
Temporary teeth requiring extraction ...		8436	
			18,009
Permanent teeth requiring filling		13,017	
Permanent teeth requiring extraction ...		6079	
			19,096
Total unsound teeth ...			37,105
Teeth already extracted		2174	
Number of sets of teeth free from decay, *i.e.* of children with sound teeth	1508		
Percentage of children free from caries	14.2		

1 "The Relation of the Dental Profession to Public Health", *Journal of the British Dental Association*, July, 1903.

2 *Interdepartmental Committee*, Vol. III, p. 99.

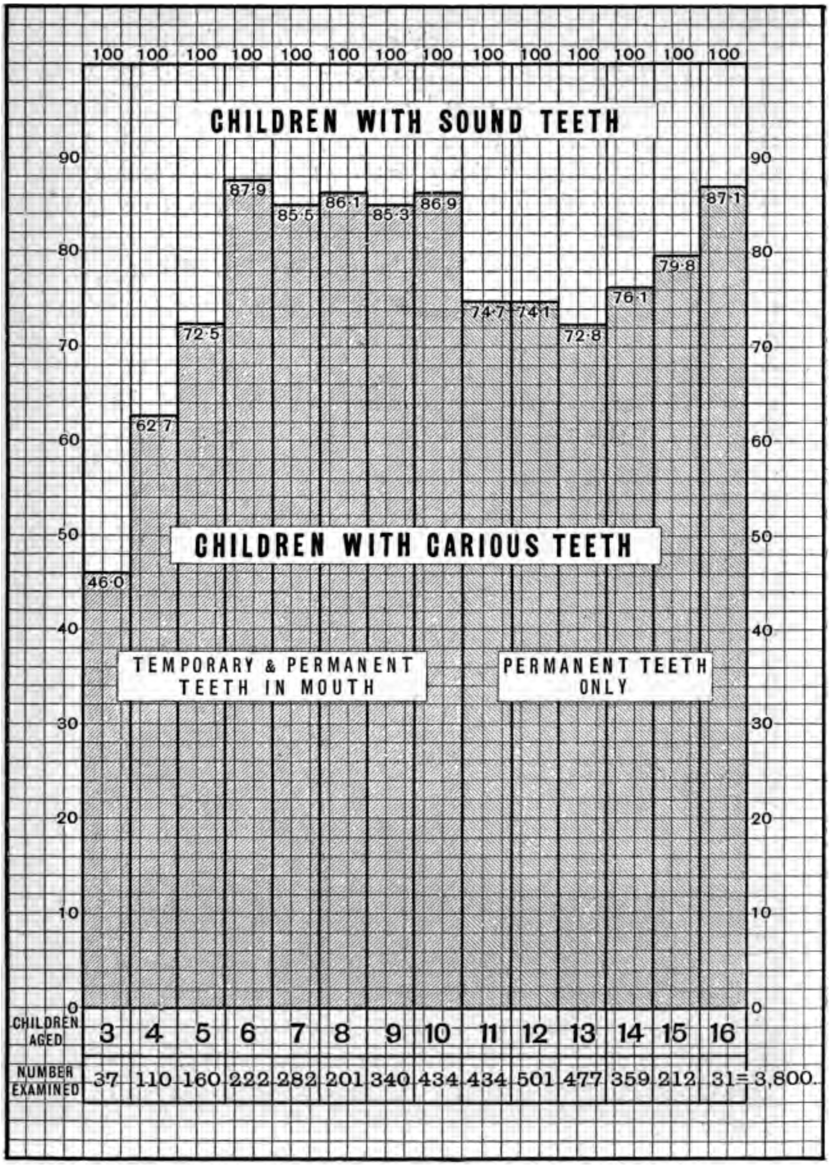


Fig. 25.—Chart showing Percentage of Sound and Unsound Teeth at various ages

Nearly 86 per cent of the children had defective teeth.

The figures of four Poor Law schools—Southall, Hanwell, Sutton, and Feltham—may be taken in detail as typical of this examination. In these schools 3800 children's mouths were examined during the years 1891 and 1892, and every tooth, both sound and unsound, was recorded as on the annexed chart.

The schools are situated within twenty miles of London, in extensive ground, where the inmates have the advantage of good air and healthy exercise. The children are gathered from various parishes in London. They are clothed, housed, fed, and educated at the public expense. In connection with each school there is a large staff of teachers, with band and drilling masters, and the children are all under expert medical supervision. These points are mentioned in order to show that the environment was generally good, and that the children were living under healthy conditions.

As a result of this examination of 3800 boys and girls, whose ages ranged from three years to sixteen years, 828 had sound dentitions, 2972 had 10,696 carious teeth, or 3.5 each. Percentage of sound teeth, 21.8; percentage of unsound teeth, 78.2.

Fig. 25 shows the percentage at various ages of sound and unsound teeth. It illustrates the early age at which caries commences in otherwise healthy children, and shows how, when unchecked, it gradually increases until the age of seven years. Then the first permanent masticating tooth has emerged from the gum, and the temporary teeth in the front of the mouth are beginning to disappear. At ten years of age most of the temporary teeth should have naturally disappeared. This stage is coincident with the drop in the percentage of carious teeth from 86.9 to 74.7. Fourteen hundred and sixty (1460) children aged from three to ten years had 3187 temporary teeth which needed filling, and 1213 which needed extraction—or 3 defective teeth for each child. Eighteen hundred and twelve (1812) children aged from ten to sixteen years had 1278 temporary teeth which

Metropolitan area, thus proving that there is an increasing recognition of the need for a systematic care of the teeth.

In the case of children, who have not merely to maintain nutrition but also to grow, it is surely a matter of urgency that all the organs of digestion should be kept in a state of functional integrity; and if, as seems to be the case, disease of the digestive tract is increasing, it is evident that any departure from the normal dentition places the child and future adult at a disadvantage. Instead of waiting until the child suffers pain, and thus directs attention to a carious tooth, it is far better, both for patient and operator, that the earliest appearance of caries should be noted, and its progress prevented by a regulated system of inspection and by prompt treatment. Under such circumstances dental disease and the necessity for painful operations become reduced to a minimum, and at the same time the function of mastication is retained. The facts above recorded prove the necessity of impressing upon all concerned with children the need for constant dental supervision, whether it be parents, Poor Law guardians, who stand *in loco parentis*, or the managers of public and private schools.

In order to show what can be done to remedy and keep in check dental disease, the following statement has been furnished by the dental surgeon of the Hanwell schools, based upon his reports issued to the guardians during the past ten years from 1897 to 1907. The average number of children in the school is 836. The yearly average is—

Mouths inspected	1328
Temporary teeth filled	24
Temporary teeth extracted	357
Permanent teeth filled	413
Permanent teeth extracted	86
Scaling cases	39
Regulating cases	16

It should be mentioned that the boys in the Poor Law

schools are either taught a trade or enter the army or navy. The girls are trained for domestic service.

During the past ten years, 1897 to 1906, 7460 trained boys and 5369 trained girls—12,829 in all—were placed out by the guardians from the Metropolitan Poor Law schools alone. The vast majority of these children have been under dental supervision for years, whereas such children, before the condition of their teeth was recognized, had never known the use of a toothbrush.

Such treatment is not only beneficial to themselves but to those who employ them, for boys with healthy mouths will make all the better soldiers and sailors, and girls will perform their domestic duties to much greater advantage.

In this direction there is much hope for the future. The introduction in 1907 of medical inspection of school children in England, which includes inspection of the teeth, shows that this has become a national question, and it will reveal facts which of necessity must be followed by treatment, and this treatment will be the means of preventing a vast amount of disease the origin of which has hitherto been obscure.

The question of heredity, so far as dental diseases are concerned, remains unanswered. We are constantly in contact with parents who have fairly strong teeth, but whose offspring may show early signs of weak dental tissue. On the other hand, it is an undoubted fact that parents whose teeth are weak have offspring whose teeth show very early signs of dental disease. It should, however, be remembered that we have not sufficient data to come to a definite conclusion. The issues are obscured by environment at almost every stage in such an enquiry. We believe, however, that too much stress has been laid upon heredity and not enough on environment.

The majority of infants are born healthy, and it has been already proved that the mortality among infants after the first week of life is largely due to ignorance and neglect. There is no reason why healthy children should not have strong and sound dental tissue. This has been referred to

in Chap. II, when the building up of the teeth was considered, and here we may give an example of what occurs in our very midst. The marked absence of Jewish children from our hospitals for dental treatment—and this is especially so at the Evelina Hospital, Southwark, founded by a noble Jew, Baron Ferdinand Rothschild—has led to the enquiry: Have the poor Jews better teeth than the Gentiles? Dr. Hall, of Leeds, and many other observers have answered this question in the affirmative.[1] This may be due to the inherent capacity of the race—in other words, heredity,—but probably still more to environment and parental care.

Apart from the custom which places him under ecclesiastical authority in the method and preparation of his food, apart too from his abstemious habits as to alcohol, the poorest Jew will take care of his wife both before and when she is a mother. He will not allow her to earn money in a factory or elsewhere unless under extreme necessity. The mother also will feed her babe at the breast, and use care and discrimination with regard to her own food and that of her offspring.

These are in brief the important factors which enable the alien, often very poor, whose teeth are worn down by the dark, coarse bread of a foreign land, to rear children of splendid physique and with excellent teeth, who are eager and apt to learn in our English schools.

A summary of the previous chapters will, we think, be a suitable conclusion to this book.

And first, in order to render the subject both comprehensive and clear, it has been shown that the teeth are pieces of bodily tissue, and may stand as types of the fabric of the living frame; that they, like all tissues, are made up of cells, formed into systems; and that by their interrelationship the systems of the tissues make a complete working organism, the human body, in which the teeth exercise important functions.

Tracing the formation of the teeth from a very early age

[1] *Interdepartmental Enquiry into Phys. Det. The Worship of the Body,* Dr. Hall.

by means of microscopical sections, we have explained their building up from the tissues of the jaw, and considered their supplies for proper growth.

A brief description of the infant with its teeth embedded in the jaws has enabled us to emphasize the necessity of natural food for its sustenance, as well as for the vigorous growth and development of the teeth.

The completion of the crowns of the teeth at a very early age proves that strong or weak dental tissue is formed in infancy or early childhood, and we believe that this is for the most part determined by parental control and intelligence.

An explanation of the eruption of the teeth—that is, their emergence above the gum—led to the consideration of the necessary food for their exercise and their future development in the jaws.

The evil effects upon the temporary teeth, and their permanent successors, of soft foods, also of foods deprived of all fibrous particles—as illustrated by the modern steel-milled flour—has been pointed out.

Reference has been made to the importance of the temporary teeth during a critical period of child life, and to the general ignorance prevailing on the subject.

The need of early habits in cleansing the mouth has been emphasized.

The absorption of the temporary teeth, their natural removal from the jaws, their retention when diseased, and their replacement at certain ages by the permanent teeth have been described and illustrated.

In order to show the influence of bacteria upon the teeth, a detailed description has been given of dental caries, that disease by which most teeth are destroyed. This destruction of the teeth has been proved to have far-reaching results upon the body, by infection and by lowering the general nutrition, thus paving the way for other diseases of bacterial origin, such as consumption, pneumonia, and appendicitis.

The evidence of the past proves that dental diseases have prevailed in all ages.

The present conditions prove that dental disease is the most prevalent of all diseases.

The methods of keeping dental diseases in check by systematic inspection, by systematic treatment, and by constant cleanliness of the mouth show that much may be done towards its prevention in private and public life.

We believe that these facts, bearing as they do on the welfare of the community, ought to be widely known, and for that reason we have endeavoured to show how teeth are built up, why they are destroyed, and how they may be preserved.

APPENDIX

In order that parents and teachers may be able to inculcate rtain elementary truths for the "hygiene of the mouth" e following summary has been added:—

1. The mouth is a gateway of health or disease.
2. Hard foods, if well masticated, help to make and keep good teeth.
3. Soft foods cling to teeth; hard foods clean them.
4. All foods should be eaten slowly.
5. Deliberate mastication aids digestion.
6. Drinking is best after eating.
7. A clean mouth makes a sweet breath.
8. Food left on teeth brings decay.
9. Wash the mouth after every meal.
10. All decay commences on the outside of teeth.
11. Unclean teeth decay chiefly at night.
12. Clean the teeth before going to bed. Take no food of any kind afterwards. Clean the teeth again in the morning.
13. Use a small toothbrush with stiff bristles. Use a little soap and some precipitated chalk.
14. Brush all the teeth thoroughly, especially the back ones. Brush all surfaces of the teeth.
15. The teeth *must* be kept clean.
16. CLEAN teeth SELDOM DECAY.